UNITED STATES
AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 1989/90
FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
the AERG staff

April 1990

ADMINISTRATIVE REPORT LJ-90-11

Southwest Fisheries Center
Antarctic Ecosystem Research Group

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U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center
P.O. Box 271
La Jolla, CA 92038

TABLE OF CONTENTS

U.S. Antarctic Marine Living Resources (AMLR)
1989-90 Field Season Report

The 1989-90 AMLR field season consisted of an integrated research program designed to elucidate the relationships between Antarctic krill, their predators, and key environmental parameters. Field activities were conducted aboard the NOAA Ship *Surveyor* around Elephant Island, land based sites at Palmer Station and Seal Island, and sea ice activities from *Surveyor*-based small boats near Ross Island in the Weddell Sea. In addition, ancillary research projects were completed on the round-trip transit runs aboard the vessel between San Diego and Punta Arenas, Chile.

Cruise: AMLR 1990 (Pacific Marine Center Cruise SU-89-02)

Vessel: NOAA Ship *Surveyor*

Operating Area: Elephant Island, Antarctica (see Figure 1)

Description: The spatial distribution of krill, the physical structure of the upper water column, the spatial distribution of primary productivity, and the foraging patterns of land-based krill predators were mapped over a 100 by 100 mile study area centering on Elephant Island. Marine mammal and bathymetric observations were also collected throughout the cruise.

Itinerary: Depart Seattle 27 November 1989
Return to Seattle 16 April 1990
124 days at sea; 17 days in port

		Sea Days	Port Days
Transit Seattle to San Diego	11/27 - 12/01	5	
Port call in San Diego	12/01		1
Transit San Diego to Valparaiso	12/03 - 12/20	18	
Port call in Valparaiso	12/21 - 12/23		3
Transit Valparaiso to Punta Arenas	12/24 - 12/29	6	
Port call in Punta Arenas	12/30 - 12/31		2
Leg I	01/01 - 01/30	30	
Port call in Punta Arenas	01/31 - 02/03		4
Leg II	02/04 - 03/05	30	
Port call in Punta Arenas	03/06 - 03/07		2
Transit Punta Arenas to Iquique, Chile	03/08 - 03/15	8	
Port call in Iquique	03/16 - 03/18		3
Transit Iquique to San Diego	03/19 - 04/09	22	
Port call in San Diego	04/10 - 04/11		2
Transit San Diego to Seattle	04/12 - 04/16	5	
		124	17

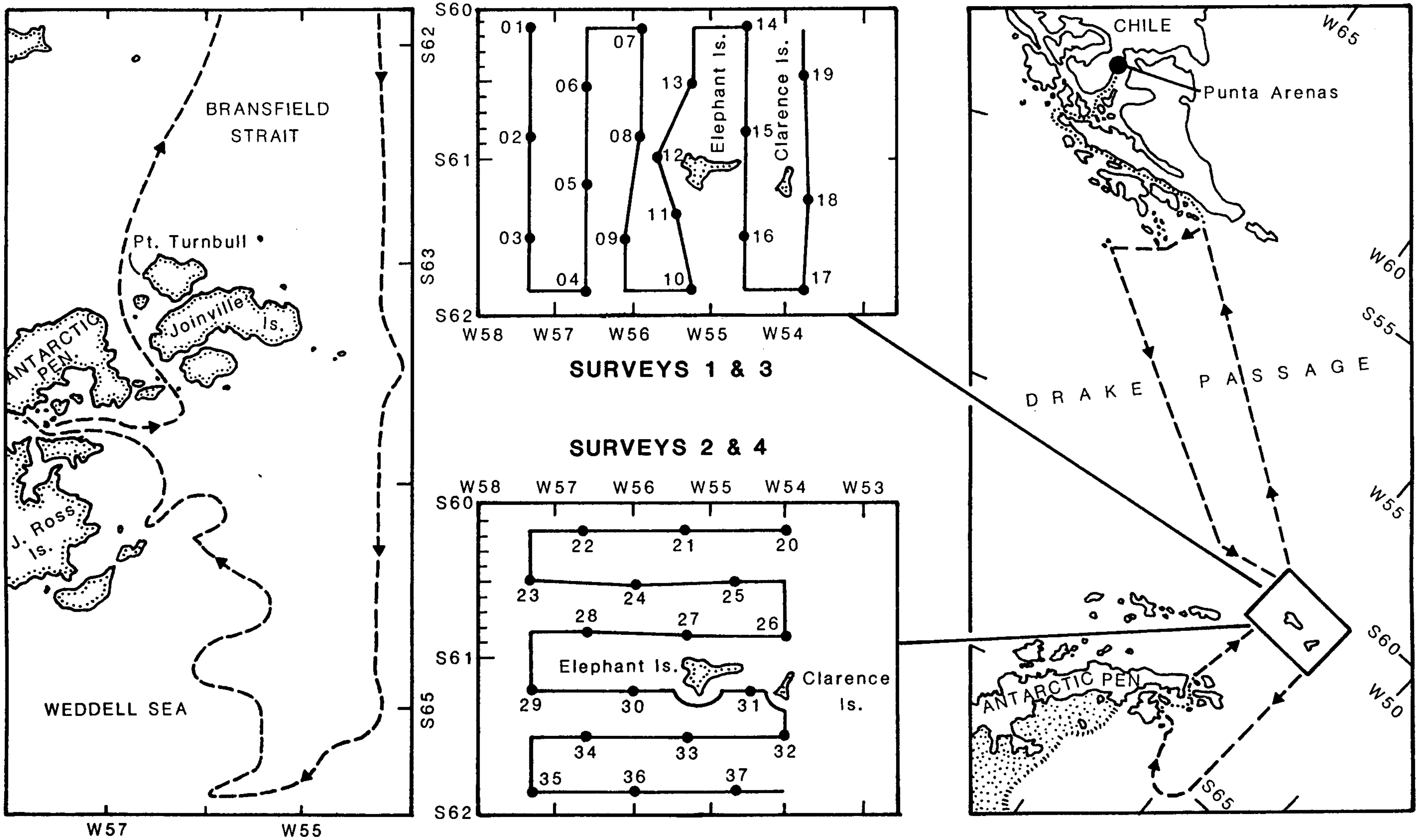


Figure 1. AMLR 1990 transit tracklines and study area, Legs I and II.

DESCRIPTION

Leg I

The NOAA Ship *Surveyor* departed Seattle on November 27, 1989 and called at San Diego on December 2-3. Detailed bathymetric data were collected using the *Surveyor's* multi-swath sonar system (Seabeam) along a GEOSAT trackline from San Diego to the Sala y Gomez Ridge west of Peru; 48 hours were spent surveying the Ridge (see Appendix Section A.1). The geologist participating in the Seabeam data collection left the ship during the port call at Valparaiso (December 21-23) and two marine mammal observers came aboard for the passage to Punta Arenas (December 24-29), Leg I and Leg II (see Section 12). The remainder of the scientific party joined the ship during the first port call in Punta Arenas (December 30-31). The Seal Island camp was reprovisioned on January 5, 1990 and the first of four surveys was conducted around Elephant Island from January 6 through 11. The surveys consisted of hydroacoustic transects (see Section 3), interrupted with bongo tows (see Section 2), CTD's (see Section 1), and rosette casts (see Section 4) at fixed stations. Predator tracking studies were conducted from January 12 through 20 (see Section 9); hydroacoustic data and bongo and MIK net samples were obtained concurrently. Survey 2 was conducted from January 21 through 26. MOCNESS tows were conducted on an opportunistic basis when a dense layer of krill was detected with the acoustic system and seas allowed its deployment (see Section 2). Seabeam data were collected along a transect from Isla Diego Ramirez to a point north of Livingston Island, along part of the South Shetland Trench, over the Elephant Island study area, and along the Shackleton Fracture Zone (see Section 11). At the Seal Island shore camp provisions were landed, a health and safety inspection was conducted and telecommunications capability was improved (see Section 5).

Concentrations of krill were apparent along the shelf break northwest and northeast of Elephant Island during both surveys, although densities and estimated biomass were two to three times higher on Survey 2. Size distributions of krill were similar for both surveys (31-54mm standard length, 41mm mean), although average catch on Survey 2 was twice that of Survey 1. Adult forms were dominant on both surveys with the exception of one sample taken between Elephant and Clarence Islands on Survey 2 which contained a relatively large number of juvenile males. Gut fullness was generally lower on Survey 2. A front was apparent, separating Drake Passage water from Weddell Sea/Bransfield Strait water, extending SW to NE and passing to the north of Elephant Island. Chlorophyll concentrations appeared to be intermediate between the rich coastal areas to the SW and the oligotrophic waters of Drake Passage, although phytoplankton were abundant throughout the upper 50-75m of the water column. Relatively low phytoplankton biomass was encountered to the north of Elephant Island and higher biomass to the south and east of the island; cell sizes were larger than that generally found in Antarctic waters. Five fur seals, three macaroni penguins and 3 chinstrap penguins were tracked north from Seal Island to their apparent foraging areas; foraging ranges correlated with attendance patterns observed ashore for each species (18-100km for fur seals, 20-35km for macaronis, 11-24km for chinstraps). These generalizations should be regarded as only preliminary impressions; additional insights are expected with more thorough examination of the data sets.

Leg II

The *Surveyor* departed Punta Arenas, Chile on 4 February 1990 for Elephant Island, Antarctica. Survey 3 was conducted from 7 February through 13. Survey 4 in the study area was conducted from 21 February through 27. The surveys were replicates of the first two surveys conducted during Leg I. Hydroacoustic transects were traversed (see Section 3); bongo net tows (see Section 2) and CTD (see Section 1) and rosette casts (see Section 4) were again collected at designated stations. Between 16 February and 19 February satellite transmitters were place on crabeater seals located east of Seymour Island in the northwestern Weddell Sea. In addition, specimen material for studies of crabeater seal age structure, reproductive status, physiological condition, and food habits were collected (see Section 10). On 27 February, the field station at Seal Island was closed and personnel embarked the ship. On 1 March, the U.S. CCAMLR Inspector boarded the Japanese FV *Aso Maru* to determine compliance with rules and regulations specified by the CCAMLR System of Observation and Inspection (see Appendix Section A.5). On 2 March the ship departed Antarctica across the Drake Passage and returned to Punta Arenas, Chile on 5 March 1990. Participating Chilean scientists collected bathythermometric data from transects across the Drake Passage on both legs of the cruise (see Appendix Section A.3). A census of seabirds over the continental shelf of Peru from 15°S to 5°S was completed during the northbound transit from Iquique, Chile (see Appendix Section A.2).

Bongo net sampling revealed overall abundances and mean abundance estimates for krill that were considerably lower in Survey 3 as compared to both surveys in Leg I. Krill abundance increased again in Survey 4 (97 total specimens), and the mean abundance estimate was three times greater. Size distributions of krill were similar for both surveys (37-53mm standard length, 44mm mean). Almost all individuals on both surveys were reproductively mature, and no juveniles were collected. Mean gut fullness was comparable in Surveys 3 and 4 (>50%), with one station in Survey 4 at >75%. Acoustic sampling data agreed with the abundance trends obtained from the bongo net data. No large "super-swarm" of krill was observed this year. A general increase in the mixed layer depth and temperature was observed in Leg II as compared to Leg I. Chlorophyll maxima were deeper in Leg II (from 40 to 70m) than in Leg I. Higher chlorophyll values seemed to be correlated with eastern Bransfield Strait water. In size-fractionated samples, 60-90% of the total crop in Leg II was nanoplankton. Transmissions from satellite-linked transmitters deployed on crabeater seals to monitor their seasonal movements (geographical locations) and feeding ecology (dive duration, depth, and type) were received by the Argos data processing center.

Land-Based Research

The AMLR program has established a field camp at Seal Island, South Shetland Islands, in support of land-based research on marine mammals (pinnipeds) and birds (penguins and petrels) during the austral summers (see Sections 6 and 7). This season the Seal Island field team arrived at the field camp on 14 December 1989 and remained until 27 February, 1990. In addition, research on aspects of the ecology of Adelie penguins continued at Palmer station; this work is jointly funded by NSF and the AMLR program (see Section 8). This year's work at Palmer station began on 5 January and ended on 13 March 1990.

Pinniped research this season included monitoring pup growth and condition and adult female foraging trips of Antarctic fur seals, as well as other directed research on fur seals and all other pinnipeds on the island. Initial interpretations of the data indicate that reproduction, foraging effort and diet were similar to those of previous seasons. Preliminary analyses indicated that pup growth rates were slightly lower than in the last two seasons. Seabird research at Seal Island revealed, with few exceptions, the highest reproductive success observed for chinstrap and macaroni penguins in the past 3 years. At Palmer Station, indices of Adelie penguin breeding success showed an overall decrease in comparison to last season. As in past seasons, krill was the main component of the Adelie diet; however, the predominant krill size class was significantly smaller than last season.

OBJECTIVES, ACCOMPLISHMENTS, DISPOSITION OF DATA AND TENTATIVE CONCLUSIONS

1. Physical Oceanography Studies, Leg I and Leg II; submitted by Anthony Amos and Margaret Lavender.

1.1 Objectives:

The main objective of the physical oceanography program was to describe the upper ocean water structure around the Elephant Island group in relationship to the observed distribution of biological organisms. The field work aboard *Surveyor* was accomplished in two legs. This report covers Leg I, from 1 January 1990 through 30 January 1990 and Leg II, from 4 February 1990 through 5 March 1990. The second leg was a repeat of the first leg, with an additional objective to examine the temporal variation in the hydrography of the region as the austral summer progressed. A secondary objective of this study was to monitor the overlying meteorological regime during the cruises to aid in understanding the mechanisms maintaining the upper mixed layer and pycnocline.

1.2 Accomplishments:

CTD STATIONS

The sampling grid included thirty-seven stations occupied once each leg. Each leg was comprised of two separate 7-day surveys, separated by nine days while the predator-tracking program was in progress. Station 4 of Leg II was skipped due to equipment problems. Data were collected using a Sea-Bird SBE-9 CTD with a General Oceanics rosette sampler. For each leg, the ship first made a survey following a north-south grid, and then a survey following an east-west grid. On the east-west grid, CTD stations were located in between those done on the north-south grid. Temporally, the network of stations may be viewed as one non-synoptic station grid, or two quasi-synoptic grids. After Survey 1, the CTD station depth was increased to 750m where bottom depth permitted. Two additional (deep) CTD stations were occupied in the study area during Leg I. Three deep stations were made across the Antarctic Polar

Front (APF) en route to Punta Arenas at the end of Leg I. Of these three deep stations across the APF, weather conditions only permitted resampling of the two southerly stations at the end of Leg II.

At each CTD station (on the uptrace), ten or eleven water samples were collected, one at depth and the others from 100m to the surface, at depth intervals suitable for chlorophyll-a sampling. Chlorophyll, ATP and nutrient sampling was done by O. Holm-Hansen's group. All water samples were analyzed for salinity by *Surveyor's* survey technicians using the ship's Guildline Autosal salinometer. This was done to keep track of any drift or offset in the CTD's conductivity output and to assure the depth from which the water samples were collected. On most of the shallow CTD casts, a SeaTech 25-cm transmissometer and a Biospherical Instrument's light meter were used to obtain continuous sea water optical information coincident with the hydrographic data.

Data was acquired at the full rate of 24 scans/sec using the *Surveyor's* rack-mounted 286 computer and SE-Bird software. Both the University of Texas Marine Science Institute (UTMSI) and ship's CTDs were used during this leg (see Section 1.5). The UTMSI CTD deck unit has new smoothing circuitry added and extra channels for the transmissometer and PAR meter. Data were stored on 44 MByte 5 1/4" Bernoulli removable cartridge disks. For each leg, over 40 MByte of raw CTD data were acquired.

Individual station and group temperature/salinity (T/S) plots were made during the cruise to aid in preliminary identification of distinct water masses found within the focused area of sampling.

WEATHER SYSTEM

An underway weather/navigation system was installed aboard *Surveyor* to collect environmental data throughout the cruise. Using a Data World 386 computer as a processor, information from the ship's Magnavox 1102/1107 GPS-Transit satellite navigation system, the ship's Coastal Climate WEATHERPAK anemometer, Weathermeasure air temperature, relative humidity and barometric pressure sensors, and three solar radiation sensors was acquired at 10-minute intervals. Sea surface temperature and salinity data, recorded to disk at 20-second intervals with the ship's SBE SEACAT Thermosalinograph during Leg I, was bin-averaged to 10-minute intervals for use in merging with the underway weather/navigation system. Later a sea-surface temperature probe was towed from the fantail, augmenting the ship's thermosalinograph, which was secured for much of the cruise.

Weathermeasure signal-conditioning units, a Hewlett-Packard model 3421-A data acquisition-control unit, both asynchronous communications ports and an IEE-488 interface feed the data into the computer. Data are stored in daily files on high-density 5 1/4" diskettes. Files are closed and re-opened each time a line of data is written to protect from accidental erasure and backed up at 0000 hours (UT) daily. At any interval, comments can be made (i.e. "Start CTD #..."), at which time a line of environmental and position data will be stored. Thus, the system provides a log of all scientific activities for the cruise. The recorded update of ship's position was utilized by the acoustics and seabeam programs.

The ship's deck log of hourly weather observations was used to compare to the underway weather/navigation system, so that any inconsistencies could be noted and accounted for.

COMPUTER PROGRAMS

Several computer programs were written during the first leg to facilitate data acquisition and to process, analyze, display and store data. Other programs were modified to customize the systems to *Surveyor's* particular equipment set up and to digitize and plot data on polar and Mercator projection maps.

1.3 Disposition of Data:

Back up data from CTD and weather log was recorded on Bernoulli cartridges stored at UTMSI. Copies of the standard level CTD, the raw CTD data for the five Drake Passage stations, and hourly averaged weather data were given to: Leg I, Ricardo Rojas (IHA, Chile); and Leg II, Alejandro Cabezas (IHA, Chile). Copies of CTD log sheets along with water column profiles of each station were given to the Chief Scientist throughout each leg. O. Holm-Hansen's group received copies of the 10-minute interval weather data, along with the raw CTD data of each station averaged to 1m intervals. Final data will be available through A. Amos, UTMSI.

1.4 Tentative Conclusions:

The study area encompasses several bathymetric and oceanographic regimes. North-to-south, the bathymetry of the Drake Passage, rises from below 4,000m in the trench-like Shackleton Fracture Zone to the continental slope and the shelf of the South Shetland Islands, of which, the Elephant Island group is the northernmost. South of Elephant Island, the station grid crosses the deep (below 2,000m) basin of the extreme northern Bransfield Strait, and in the west, barely reaches the slope of the Weddell Sea Basin.

North of Elephant Island, surface waters are those of the Continental Water Zone and its boundary (Nowlin and Clifford, 1982), characterized by a shallow mixed layer beneath which a strong temperature minimum ("Winter Water") separates surface water from the deeper Circumpolar Deep Water, the core of which rises to nearly 500m close to the continent. Surface flow is generally to the east in the Drake Passage, but immediately adjacent to the South Shetland Islands, flow is westward as water from the Weddell Sea moves around the northern tip of the Antarctic Peninsula. Within the Bransfield Strait, so-called Bellingshausen Sea water moves west-to-east and a zone called the "Zone of Intercalation" (or mixing zone) by Sievers (1982) bisects the study region. This is the westernmost boundary of the Weddell-Scotia Confluence (WSC) and it is this region of water mass boundaries that is thought to be favorable for krill production in the Elephant Island area.

Figures 1.1a and 1.1b show locations of CTD stations made during each leg of this cruise. Data from the downtrace of each station is averaged to 1m intervals and recorded on disk. It is these 1m data that are used to produce the diagrams presented here. No attempt has been made to adjust the salinity based on the sample salinities. An initial examination of those comparison data show that the values agree to better than 0.010 ppt. A typical vertical profile is presented in Figures 1.2a and 1.2b (the same station reoccupied). Tables 1.1a and 1.1b are a (modified) standard-level listing of dynamic computations from the same station as in Figures 1.2a and 1.2b. The water masses encountered are revealed by the scatter plot T/S diagram (Figures 1.3a & 1.3b). Each station is identified in this plot by its station number at the surface (S) and bottom (B). I tentatively identify five T/S types in the study area. The water types, illustrated in Figures 1.4a and 1.4b are described below.

TYPE I: Drake Passage water; warm surface water, strong sub-surface T-min ("Winter Water", approx. -1°C, salinity 34.0 ppt), Circumpolar Deep Water (CDW) near 500m.

TYPE II: A transition water; T-min near 0°C, isopycnal mixing below T-min, CDW evident at some locations.

TYPE III: Weddell-Scotia Confluence (WSC water); little evidence of a T-min, mixing with Type II, no CDW, temperature at depth generally > 0°C.

TYPE IV: Eastern Bransfield Strait water; deep temperature near -1°C, salinity 34.5 ppt, cooler surface temperatures.

TYPE V: Weddell Sea water; Little vertical structure, cold surface temperatures (near 0°C), limited to extreme SE corner of study area.

Note that these stations do not go below 750m (Stations 1 through 19 were limited to 500m), so the deeper water masses are not encountered. Figures 1.4a and 1.4b delineates the areas for each leg where each of these waters were found. Close to Elephant Island, Stations 11, 12 and 30 may belong to type IV rather than type III.

The relationship between the biology and the water masses cannot be evaluated at this time. However, a few observations will be made here. From the clarity of the water as indicated by the transmissometer, the little amount of suspended material was confined to the upper mixed layer, as was the majority of the organisms indicated by the acoustic profiles (as cursorily observed by this oceanographer). Mixed layers were generally in the 20-30m range during Leg I, with the deepest being 70m in the Weddell Sea water. An increase in the mixed layer depth was observed from Leg I to Leg II. Surface temperatures were at all stations above 0°C, and occasionally over 3°C with a general increase in temperature between the surveys of Leg I and Leg II. There was at least one front, that separating Weddell and Bransfield Strait waters from those of the Drake Passage (Bellingshausen Sea water?). The front ran SW to NE and passed to the north of Elephant Island. Much more work needs to be done on these data before these preliminary conclusions can be tested.

1.5 Problems, Suggestions and Recommendations:

Generally, the *Surveyor* and its equipment provided an excellent platform for doing CTD/rosette stations. Some problems, not yet fully resolved, were encountered with signal interruption from the CTD via the sea cable. Both UTMSI's and the ship's CTD systems were prone to communications loss causing time-outs during a station. During Leg II, the wiring leading into the UT CTD burnt-through several times. I believe this to be a sea cable or connector problem. *Surveyor* uses a three-conductor sea cable. I prefer the single conductor cable and one-piece "Y-junction" connector, despite the momentary loss of signal when a rosette bottle is tripped. The conducting cable for the CTD was shared with the MOCNESS, a heavier instrument. As a result of the wire angle deployment off the side of the ship in conjunction with the winch block, the cable occasionally jammed in the block sheave, placing strain on the conducting cable. This required retermination of the cable connection before data acquisition could continue. The UTMSI CTD was temporarily retired after Station 27 due to sea water leakage into the temperature sensor connector and subsequent corrosion and pin loss on the bulkhead connector. A new connector was installed prior to Leg II. None of these problems prevented acquisition of accurate CTD data.

The rosette bottles gave problems throughout the cruise. Leakage and non-closure of bottles were commonplace events. I believe the non-standard rosette top and bottom plates used on *Surveyor* give rise to the problems. First, the bottles are very difficult to remove or put in place compared to the standard rosette. Secondly, the bottles cannot be cocked in the standard method (i.e. with the bottom and top lanyards still clipped together. Cocking the bottles requires too much force. Thirdly, the lanyard length at one time must have been altered, and a suitable length has not yet been attained. The lanyards lead into the firing pin slots at too shallow an angle, sometimes allowing the stepping motor to rotate without releasing the pin, held in place by a too-tight lanyard. This is also affected by the rubber "springs" used to close the bottle's bungs when the rosette is fired. Some of these are too tight and some too loose or are made of the wrong kind of rubber. I should point out that these problems are not uncommon in "rosettery", and in general, reliable water samples were collected.

The output of the Magnavox GPS/Transit navigator would be enhanced if it had an RS232 option available from the manufacturer. The present 20mA current-loop option is too slow (110 baud) for data acquisition. One of the ship's Electronic Technicians built a current-loop to RS232 interface, which enabled me to obtain SATNAV data from the Magnavox, but it was still limited to 110 baud and took 45 seconds to acquire a fix. With the proper interface and a dedicated computer, *Surveyor* could automatically obtain and record underway navigation and weather data. I will leave a copy of my computer programs AMLRGPS and AMLRLOG2 aboard as an example of how these data might be acquired.

I would like to thank the officers and crew of *Surveyor* for providing excellent support for the CTD work. I am especially grateful to the deck crew and, in particular to the Electronics Technicians and survey department for all their assistance.

Round-the-clock CTD sampling stations were obtained during Leg II with the assistance of Dr. Izadore Barrett (SWFC). I am grateful to Ricardo Rojas (IHA, Chile) during Leg I and Alejandro Cabezas (IHA, Chile) during Leg II for their help.

In future AMLR work in this region, I think these results will point to a different station grid layout to fully sample the physical realm around Elephant Island. This cruise was certainly a good start towards that understanding.

1.6 Literature Cited:

Nowlin, W.D. Jr., and M. Clifford (1982) The kinematic and thermohaline zonation of the Antarctic Circumpolar Current at Drake Passage. J Mar Res Supplo. 40:481-507.

Sievers, H.A. (1982) Description de las conditiones oceanograficos fisicas, como apoyo al estudio de la distribucion y comportaminanto del Krill (estrecho Bransfield). Ser Cient Inst Antart Chileno 28:87-136.

FIGURES:

1.1a and 1.1b. Maps showing location of CTD stations. (Naming convention: SULNN, where SU=*Surveyor*, L=leg A (also called leg I) or leg B (also called leg II), NN=Consecutive station position on grid. Legs I and II.

1.2a and 1.2b. Vertical profiles of Temperature, Salinity, Light Transmission and PAR to 250m. at CTD Station 22. (as displayed on computer screen while CTD is being deployed). Legs I and II.

1.3a and 1.3b. Scatter T/S diagram of all points (at 5m intervals) for all stations. Legs I and II.

1.4a and 1.4b. T/S diagrams for four of the water mass types tentatively classified. Upper left - Type I; Upper right - Type II; Lower left - Type III; Lower right - Type IV. (Type V not shown). Legs I and II.

1.5a and 1.5b. Zones where the water mass types shown in Figure 1.4 were found. Legs I and II.

TABLES:

1.1a and 1.1b. Dynamic computations at standard (modified for CTD stations) levels for Station 22. Legs I and II.

AMLR CRUISE 1990, LEG I: STATION POSITIONS

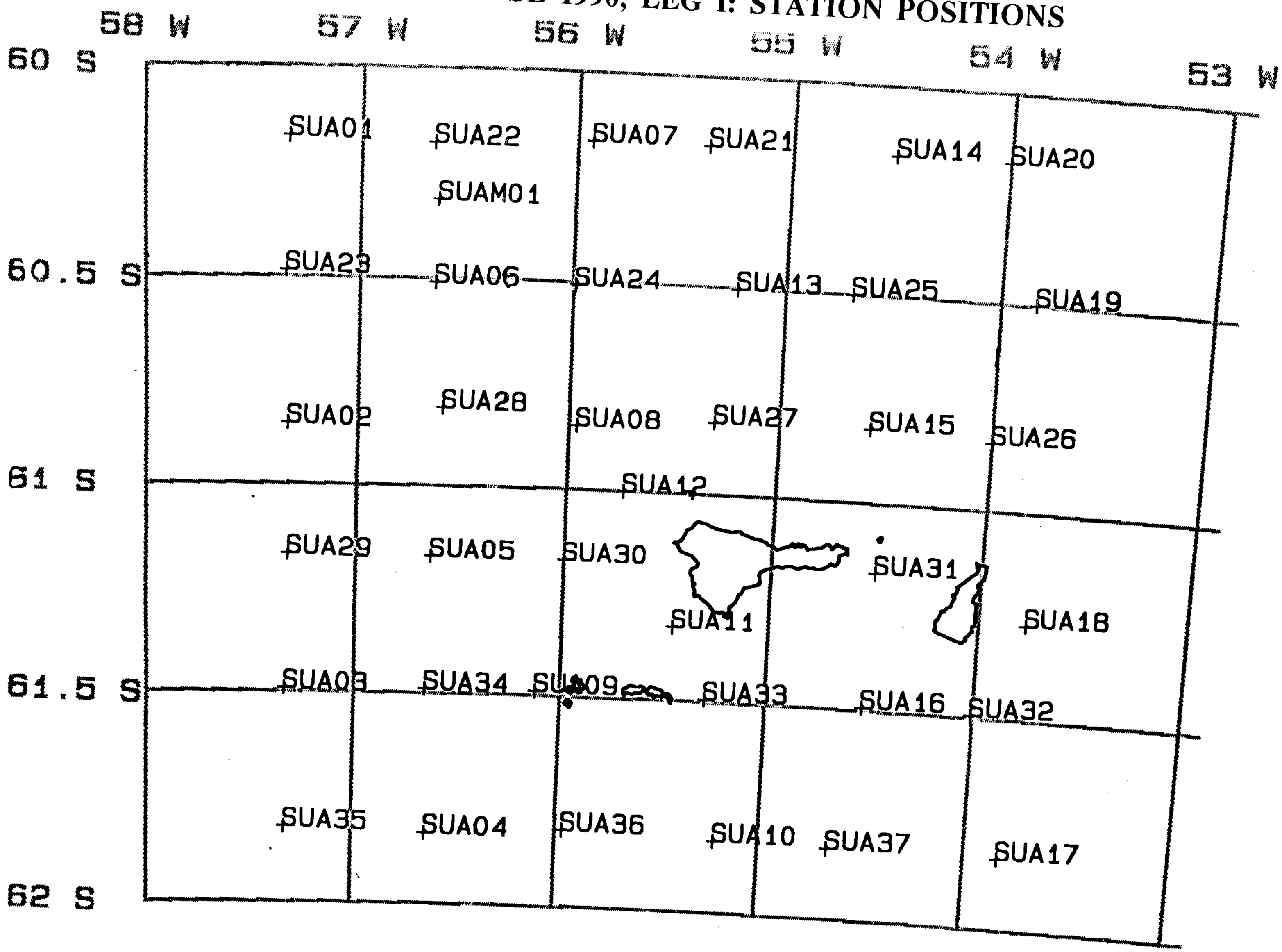


Figure 1.1a

AMLR CRUISE 1990, LEG II: STATION POSITIONS

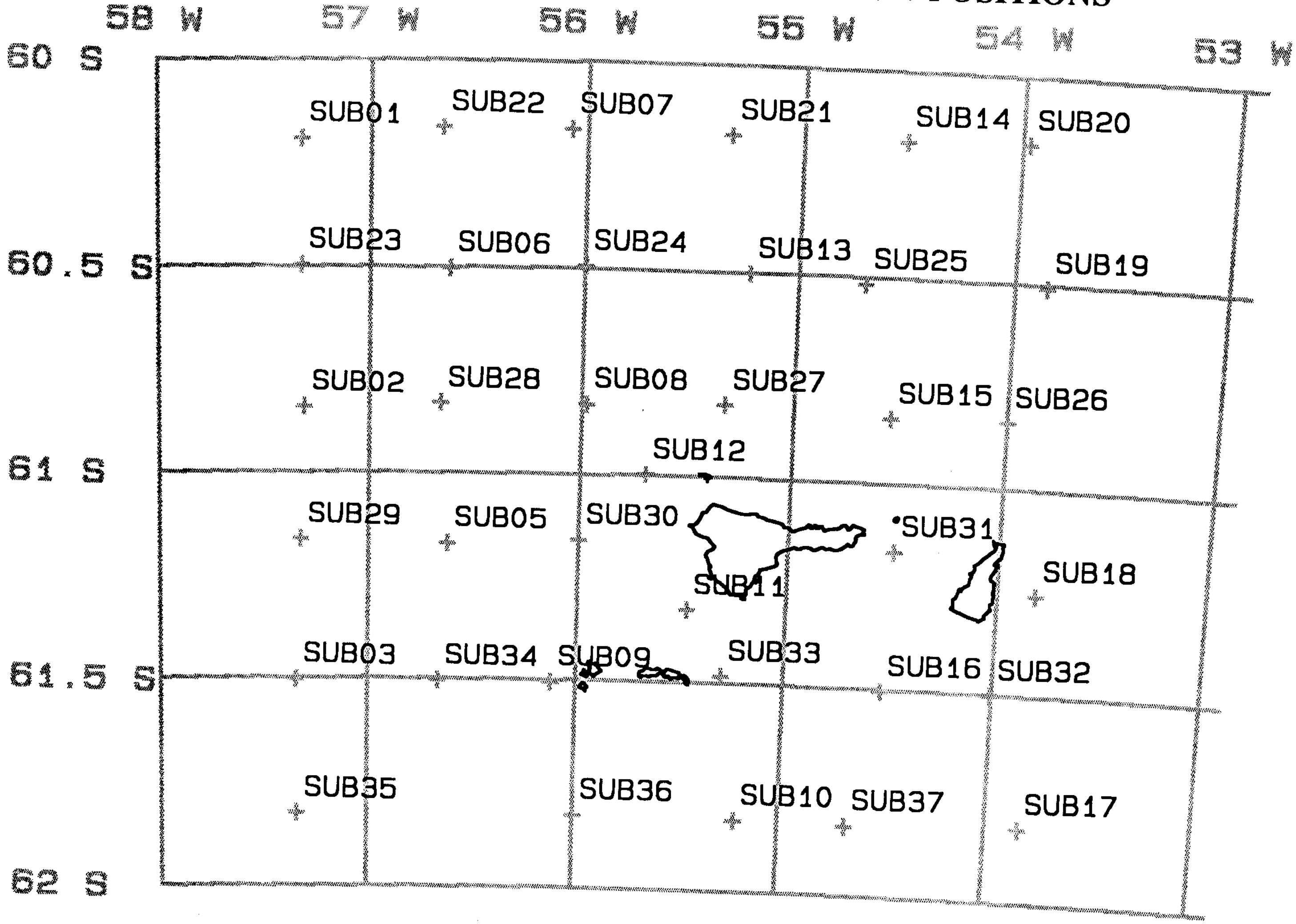


Figure 1.1b

Leg I

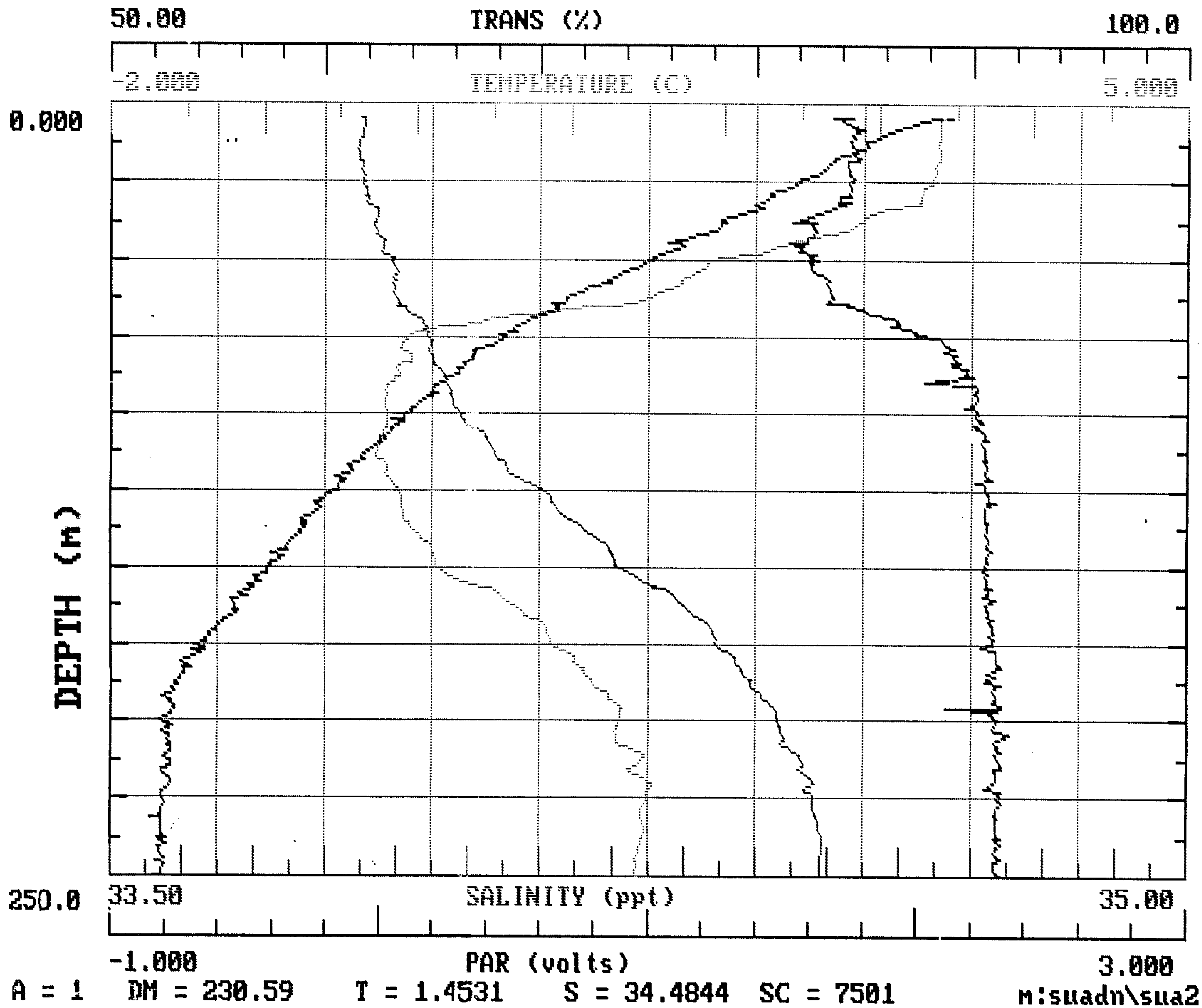


Figure 1.2a

Leg II

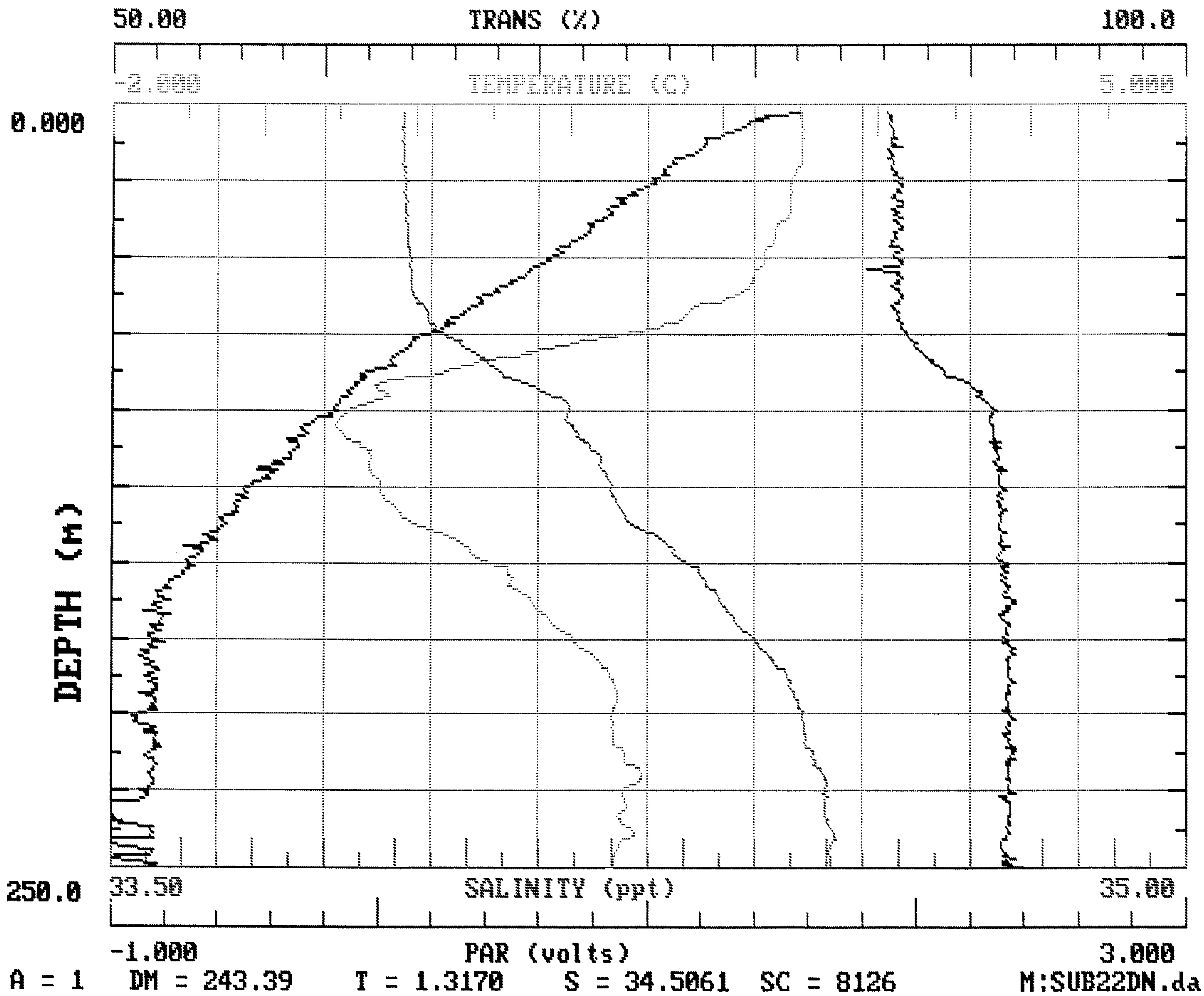


Figure 1.2b

AMLR CRUISE 1990, LEG I

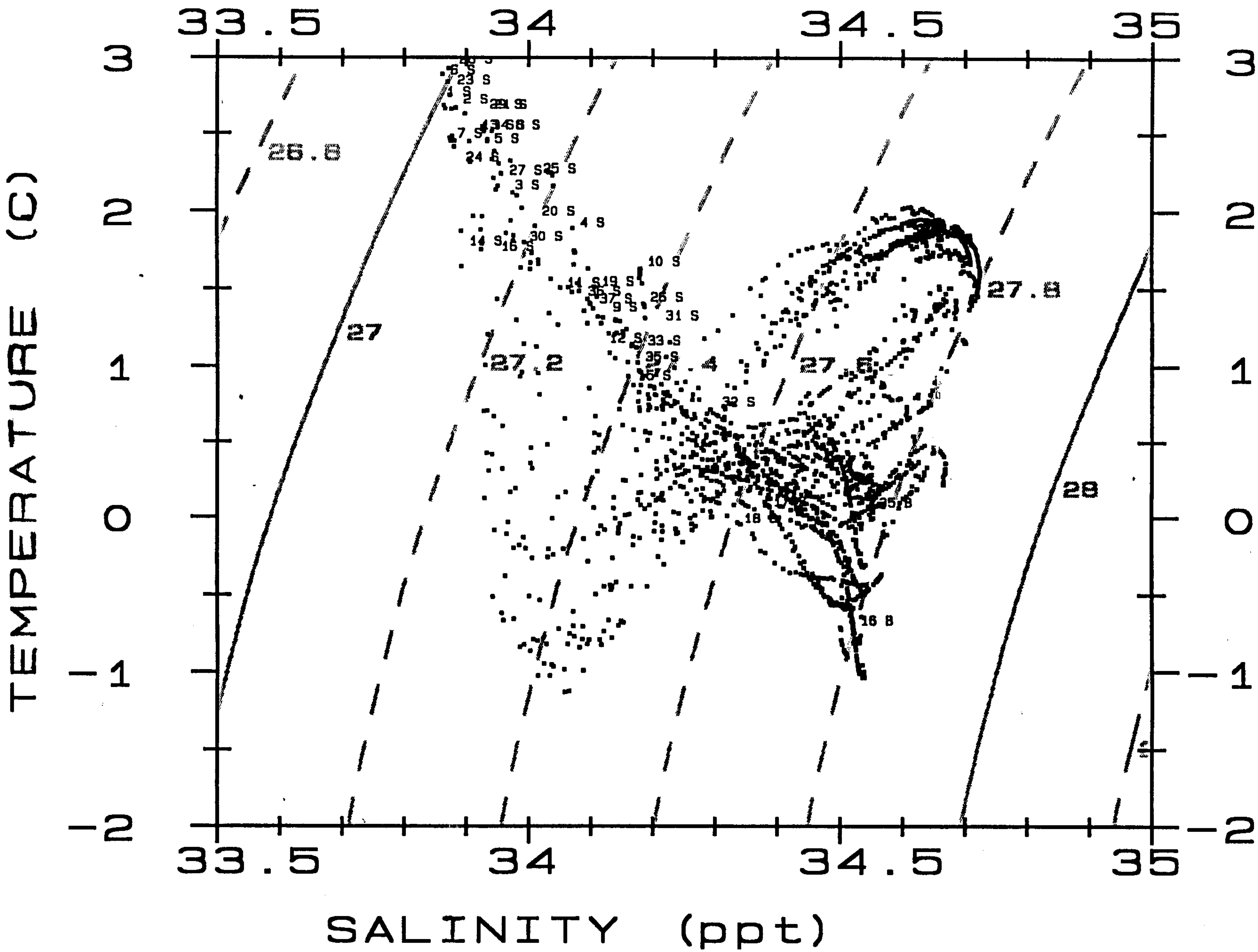


Figure 1.3a

AMLR CRUISE 1990, LEG II

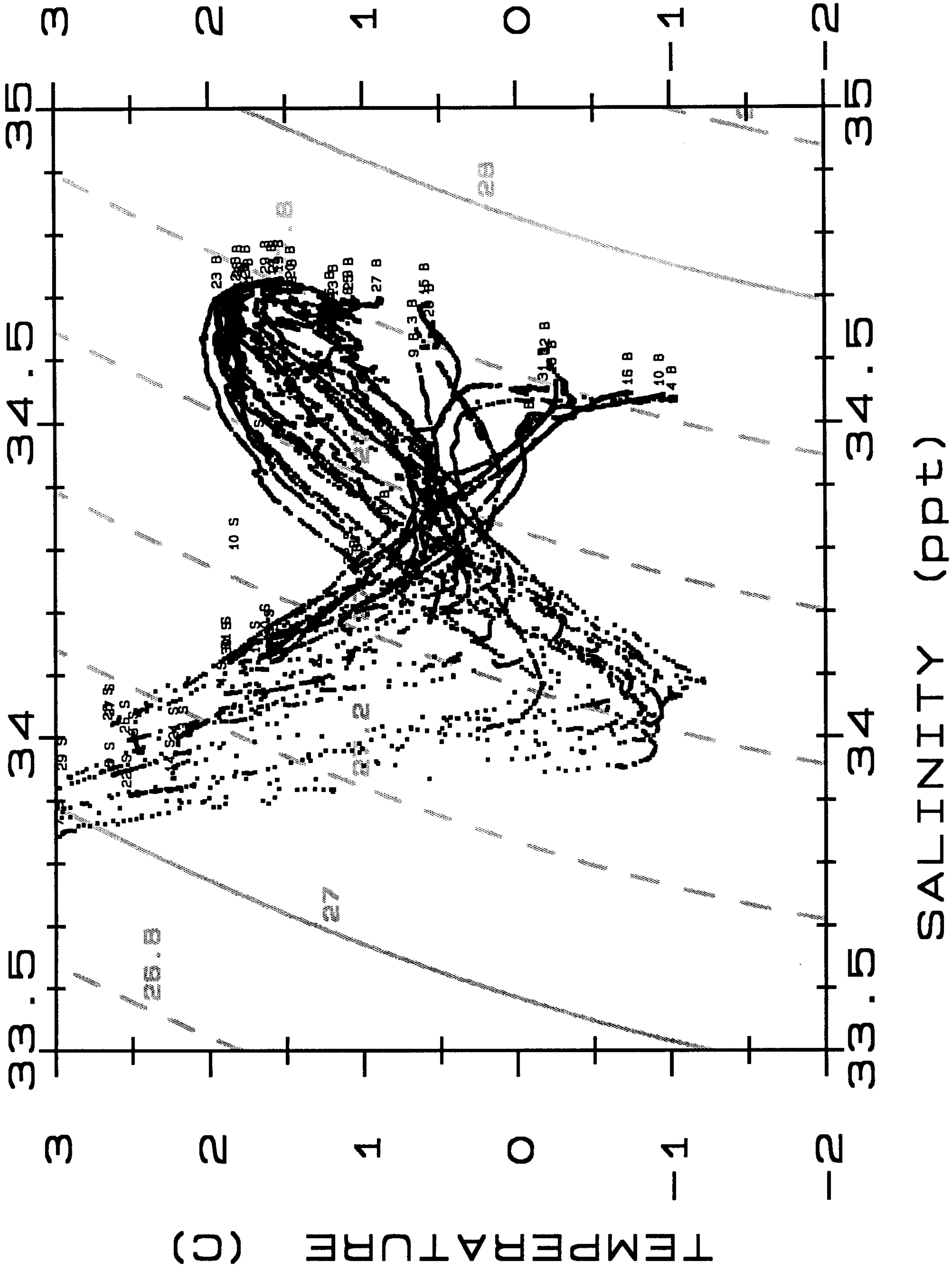


Figure 1.3b

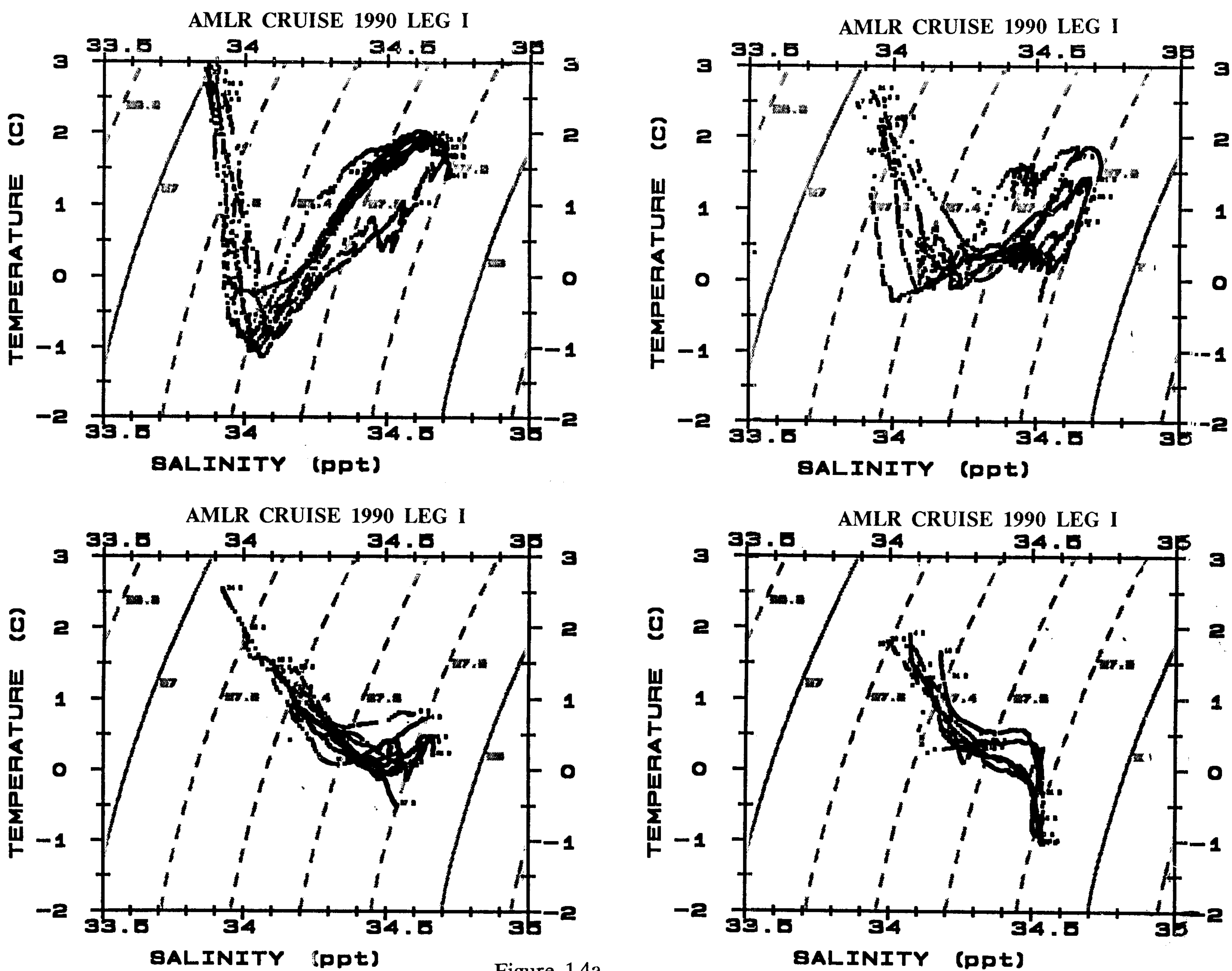

AMLR CRUISE 1990 LEG I
AMLR CRUISE 1990 LEG I
AMLR CRUISE 1990 LEG I
AMLR CRUISE 1990 LEG I
TEMPERATURE (C)
SALINITY (ppt)

Figure 1.4a

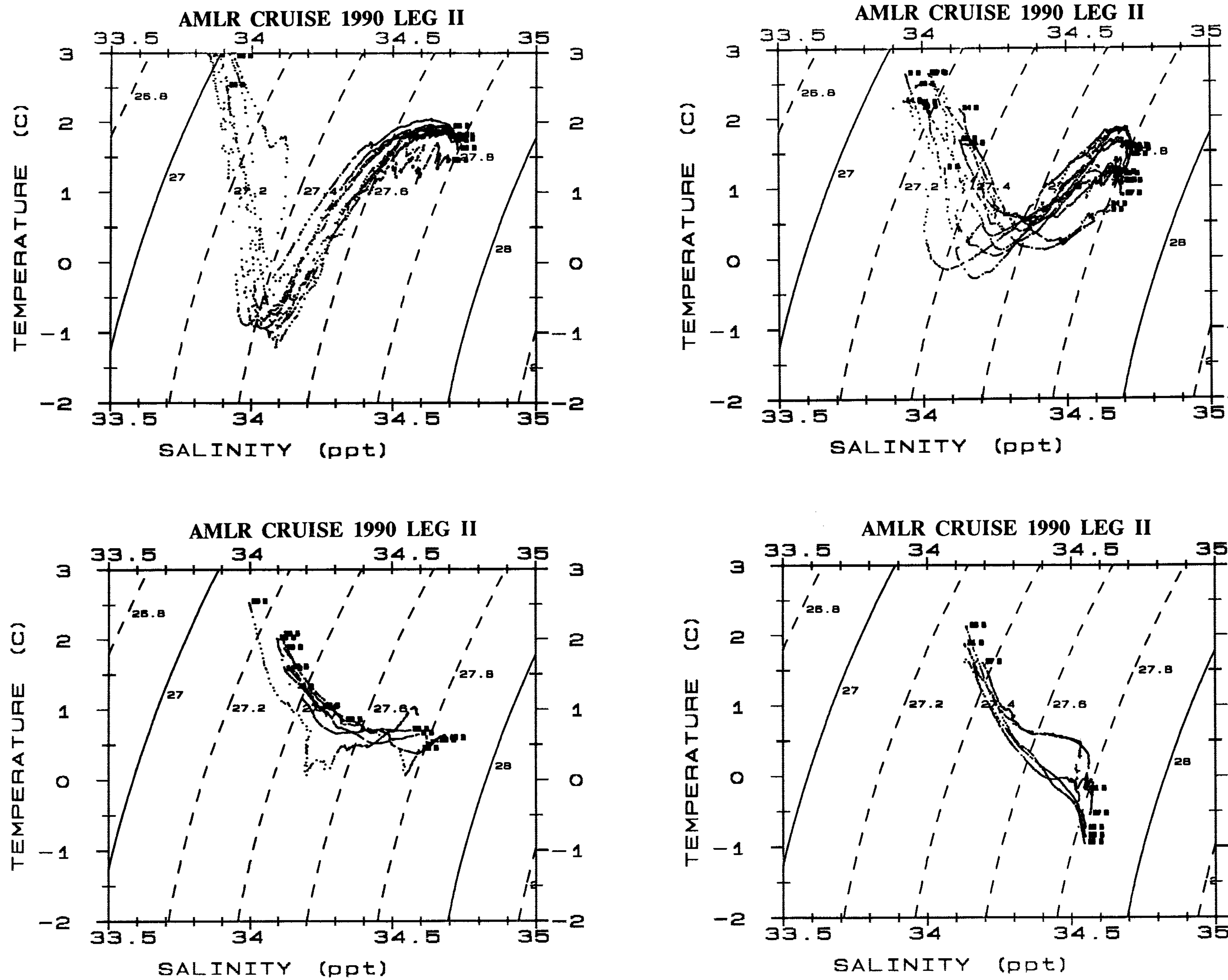
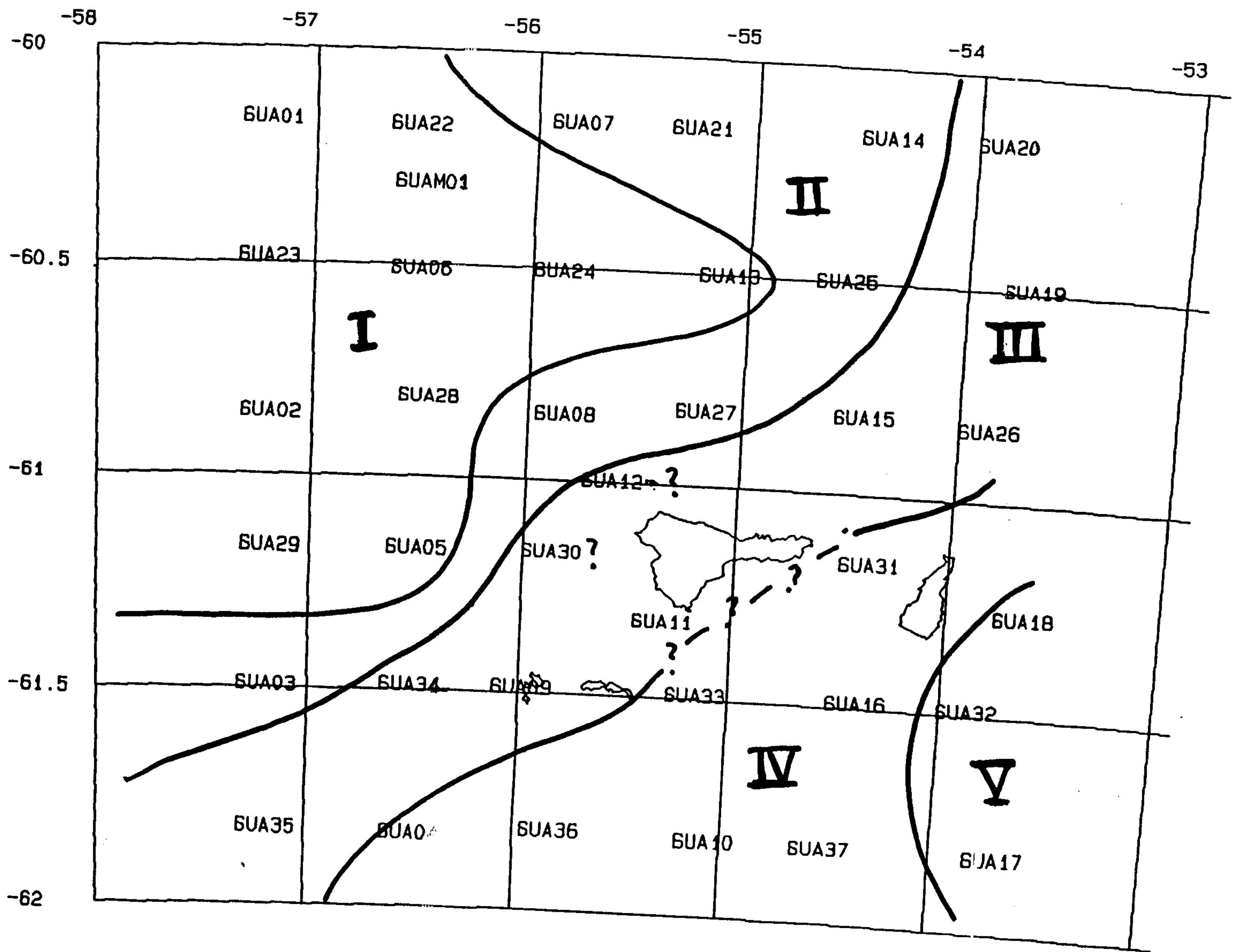

AMLR CRUISE 1990 LEG II
TEMPERATURE (C)
SALINITY (ppt)
26.8
27
27.2
27.4
27.6
27.8
28
AMLR CRUISE 1990 LEG II
TEMPERATURE (C)
SALINITY (ppt)
AMLR CRUISE 1990 LEG II
TEMPERATURE (C)
SALINITY (ppt)
AMLR CRUISE 1990 LEG II
TEMPERATURE (C)
SALINITY (ppt)

Figure 1.4b



T/S ZONES FROM LEG I (WATER MASSES)

Figure 1.5a

T/S ZONES FROM LEG II (WATER MASSES)

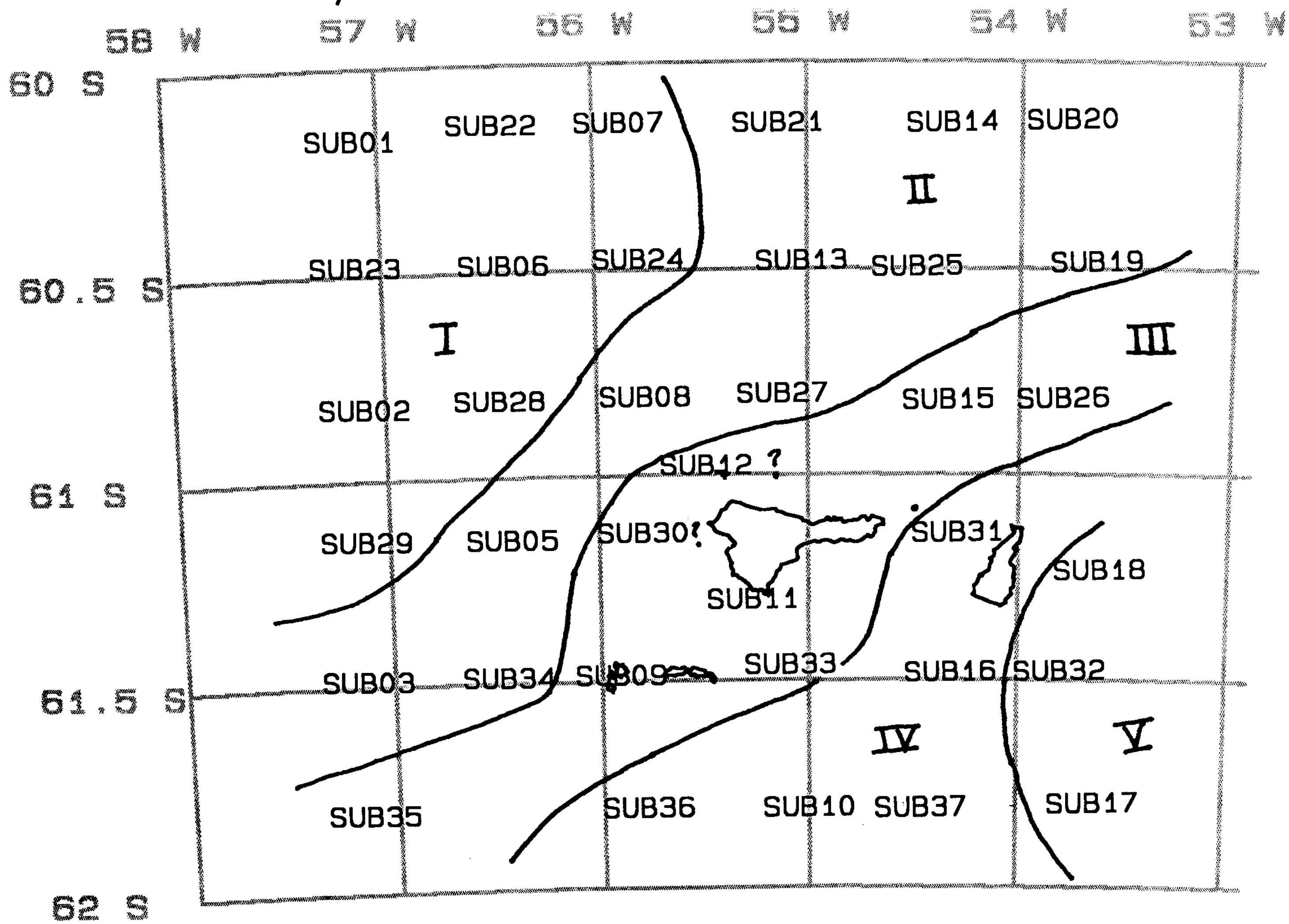


Figure 1.5b

NOAA SHIP SURVEYOR - AMLR CRUISE 1990, LEG I; STATION 22

STATION NUMBER	DAY	MON	YEAR	TIME (Z)	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DEPTH (M)	AIR TEMP (C)	RELATIVE HUMIDITY	BAROMETER (MB)	WIND SPEED	WIND DIR
SUA22	21	01	1990	1814	60	10.52 S	56	39.51 W	3751	4.0	89.8	995.7	33.2	197

DEPTH	TEMP	THETA	SALIN	SIG-T	SIG0	SIG1	SIG2	SIG3	SIG4	ANOM	DYNHT	SVEL	TRANS	PAR
0	3.427	3.427	33.8495	26.939	26.950	31.588	36.125	40.559	44.896	111.4	0.00	1462.9	84.1	2.149
2	3.427	3.427	33.8495	26.939	26.950	31.589	36.125	40.559	44.896	111.4	0.22	1462.9	84.1	2.149
4	3.408	3.408	33.8532	26.944	26.955	31.594	36.131	40.565	44.902	111.0	0.44	1462.9	84.3	2.062
6	3.406	3.406	33.8532	26.944	26.955	31.595	36.131	40.565	44.903	111.0	0.67	1462.9	84.3	2.047
8	3.395	3.394	33.8525	26.945	26.956	31.595	36.132	40.566	44.904	110.9	0.89	1462.9	84.7	1.925
10	3.394	3.393	33.8516	26.944	26.955	31.595	36.131	40.566	44.904	111.0	1.11	1462.9	84.6	1.881
12	3.390	3.389	33.8462	26.940	26.951	31.591	36.128	40.563	44.900	111.4	1.33	1462.9	84.6	1.836
14	3.385	3.384	33.8458	26.940	26.952	31.591	36.128	40.563	44.901	111.4	1.56	1462.9	84.6	1.784
16	3.395	3.394	33.8459	26.939	26.951	31.590	36.127	40.561	44.899	111.5	1.78	1463.0	84.7	1.730
18	3.394	3.393	33.8474	26.941	26.952	31.591	36.128	40.563	44.901	111.4	2.00	1463.0	84.6	1.691
20	3.359	3.358	33.8510	26.947	26.958	31.598	36.136	40.571	44.910	110.8	2.22	1462.9	84.1	1.679
22	3.370	3.369	33.8520	26.947	26.958	31.598	36.135	40.570	44.909	110.8	2.45	1463.0	84.3	1.600
24	3.355	3.353	33.8529	26.949	26.960	31.600	36.138	40.573	44.912	110.6	2.67	1463.0	84.6	1.575
26	3.333	3.331	33.8566	26.954	26.965	31.606	36.144	40.580	44.919	110.2	2.89	1462.9	84.5	1.551
28	3.279	3.277	33.8566	26.959	26.970	31.613	36.152	40.589	44.930	109.7	3.11	1462.7	84.4	1.515
30	3.269	3.267	33.8583	26.961	26.972	31.615	36.155	40.592	44.933	109.5	3.33	1462.7	84.1	1.436
35	2.954	2.952	33.8722	27.002	27.012	31.663	36.211	40.655	45.003	105.7	3.88	1461.5	83.0	1.366
40	2.817	2.815	33.8696	27.012	27.022	31.677	36.228	40.676	45.026	104.8	4.40	1460.9	82.5	1.246
45	2.399	2.396	33.8806	27.057	27.066	31.733	36.294	40.752	45.112	100.6	4.93	1459.2	82.6	1.106
50	1.934	1.931	33.8933	27.105	27.113	31.793	36.366	40.835	45.205	96.1	5.43	1457.3	83.0	.9960
60	1.645	1.642	33.8921	27.126	27.134	31.821	36.402	40.878	45.255	94.2	6.39	1456.2	83.3	.7710
70	0.425	0.422	33.9327	27.238	27.244	31.967	36.580	41.086	45.492	83.5	7.34	1450.9	86.6	.5340
80	-0.057	-0.060	33.9465	27.276	27.280	32.018	36.644	41.163	45.581	80.0	8.17	1448.9	89.2	.3790
90	-0.171	-0.174	33.9688	27.299	27.304	32.045	36.674	41.195	45.616	77.7	8.97	1448.6	89.2	.2380
100	-0.201	-0.204	33.9857	27.314	27.319	32.060	36.690	41.212	45.634	76.2	9.75	1448.6	90.2	.0980
120	-0.203	-0.208	34.0600	27.374	27.379	32.120	36.749	41.271	45.691	70.5	11.27	1449.0	90.7	-.1280
140	0.017	0.012	34.1763	27.457	27.462	32.195	36.817	41.332	45.747	62.7	12.68	1450.5	90.8	-.3100
160	0.551	0.544	34.2880	27.517	27.523	32.239	36.845	41.346	45.746	57.2	13.94	1453.5	90.8	-.5010
180	1.023	1.015	34.3719	27.554	27.561	32.263	36.856	41.343	45.732	53.9	15.08	1456.0	91.0	-.7060
200	1.308	1.298	34.4318	27.582	27.590	32.283	36.868	41.348	45.729	51.3	16.16	1457.7	91.1	-.7950
225	1.490	1.479	34.4781	27.606	27.615	32.302	36.881	41.357	45.733	49.2	17.44	1459.0	91.1	-.8070
250	1.423	1.410	34.4917	27.622	27.630	32.320	36.900	41.377	45.755	47.8	18.67	1459.1	91.3	-.8130
275	1.544	1.530	34.5321	27.646	27.654	32.340	36.917	41.391	45.765	45.7	19.87	1460.1	91.[illegible]	-.8300
300	1.637	1.621	34.5621	27.663	27.672	32.354	36.928	41.400	45.772	44.3	21.01	1461.0	91.3	-.8480
325	1.930	1.912	34.6089	27.677	27.687	32.361	36.927	41.391	45.756	43.2	22.12	1462.8	91.3	-.8440
350	1.899	1.880	34.6215	27.690	27.700	32.375	36.941	41.405	45.771	42.1	23.19	1463.1	91.2	-.8600
375	1.845	1.825	34.6226	27.695	27.705	32.381	36.949	41.414	45.781	41.7	24.25	1463.3	91.3	-.8720
400	1.838	1.817	34.6309	27.702	27.712	32.388	36.956	41.422	45.789	41.1	25.29	1463.7	91.3	-.8700
450	1.905	1.880	34.6520	27.714	27.724	32.398	36.964	41.428	45.794	40.3	27.34	1464.8	91.3	-.8630
500	1.783	1.756	34.6564	27.727	27.737	32.415	36.983	41.450	45.819	39.1	29.35	1465.1	91.4	-.8680
550	1.733	1.702	34.6676	27.740	27.750	32.429	36.999	41.467	45.836	38.1	31.31	1465.7	91.3	-.8730
600	1.725	1.692	34.6794	27.750	27.760	32.440	37.009	41.477	45.847	37.3	33.21	1466.5	91.3	-.8590
650	1.725	1.689	34.6899	27.758	27.769	32.449	37.017	41.485	45.855	36.7	35.08	1467.4	91.2	-.8470
700	1.702	1.663	34.6982	27.766	27.778	32.458	37.027	41.495	45.865	36.1	36.91	1468.1	91.2	-.8670
750	1.670	1.628	34.7041	27.774	27.785	32.466	37.036	41.505	45.875	35.5	38.72	1468.8	91.3	-.8720

Table 1.1a

NOAA SHIP SURVEYOR - AMLR CRUISE 1990, LEG II; STATION 22

STATION NUMBER	DAY	MON	YEAR	TIME (Z)	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DEPTH (M)	AIR TEMP (C)	RELATIVE HUMIDITY	BAROMETER (MB)	WIND SPEED	WIND DIR
SUB22	21	02	1990	2046	60	9.77 S	56	40.11 W	3745	2.9	87.3	994.0	26.5	210

DEPTH	TEMP	THETA	SALIN	SIG-T	SIG0	SIG1	SIG2	SIG3	SIG4	ANOM	DYNHT	SVEL	TRANS	PAR
0	2.515	2.515	33.9091	27.070	27.079	31.742	36.300	40.755	45.112	99.2	0.00	1459.0	86.4	1.472
2	2.515	2.515	33.9091	27.070	27.079	31.742	36.300	40.755	45.112	99.2	0.20	1459.1	86.4	1.472
4	2.515	2.514	33.9091	27.070	27.079	31.742	36.301	40.755	45.112	99.2	0.40	1459.1	86.4	1.427
6	2.515	2.514	33.9092	27.070	27.079	31.743	36.301	40.755	45.112	99.2	0.60	1459.1	86.4	1.417
8	2.515	2.515	33.9092	27.070	27.079	31.742	36.301	40.755	45.112	99.2	0.79	1459.2	86.3	1.348
10	2.514	2.514	33.9091	27.070	27.079	31.743	36.301	40.756	45.112	99.2	0.99	1459.2	86.5	1.283
12	2.518	2.517	33.9085	27.069	27.079	31.742	36.300	40.754	45.111	99.3	1.19	1459.2	86.4	1.253
14	2.515	2.514	33.9093	27.070	27.079	31.743	36.301	40.756	45.112	99.2	1.39	1459.3	86.3	1.204
16	2.511	2.510	33.9086	27.070	27.079	31.743	36.301	40.756	45.113	99.2	1.59	1459.3	86.5	1.157
18	2.506	2.505	33.9099	27.071	27.081	31.744	36.302	40.757	45.115	99.1	1.79	1459.3	86.4	1.108
20	2.490	2.489	33.9096	27.072	27.082	31.746	36.304	40.760	45.117	99.0	1.98	1459.2	86.5	1.091
22	2.474	2.473	33.9113	27.075	27.084	31.749	36.308	40.763	45.121	98.8	2.18	1459.2	86.6	1.068
24	2.447	2.446	33.9121	27.078	27.087	31.752	36.312	40.769	45.127	98.5	2.38	1459.1	86.7	1.003
26	2.445	2.443	33.9121	27.078	27.088	31.753	36.312	40.769	45.127	98.5	2.58	1459.2	86.6	.9920
28	2.442	2.440	33.9118	27.078	27.088	31.753	36.313	40.769	45.128	98.5	2.77	1459.2	86.9	.9570
30	2.443	2.441	33.9122	27.079	27.088	31.753	36.313	40.769	45.128	98.5	2.97	1459.2	86.5	.9350
35	2.436	2.434	33.9125	27.079	27.089	31.754	36.314	40.771	45.129	98.4	3.46	1459.3	86.6	.8670
40	2.352	2.349	33.9151	27.089	27.098	31.765	36.327	40.786	45.147	97.6	3.96	1459.0	86.6	.7820
45	2.323	2.321	33.9166	27.092	27.101	31.769	36.332	40.792	45.153	97.3	4.44	1458.9	86.8	.6810
50	2.264	2.262	33.9174	27.098	27.107	31.777	36.341	40.802	45.164	96.8	4.93	1458.8	86.6	.6470
60	2.153	2.150	33.9218	27.110	27.119	31.792	36.359	40.823	45.188	95.7	5.90	1458.4	86.6	.4470
70	1.733	1.730	33.9437	27.160	27.169	31.853	36.431	40.905	45.279	90.9	6.85	1456.8	86.8	.2620
80	0.874	0.871	34.0019	27.267	27.273	31.982	36.583	41.077	45.472	80.8	7.76	1453.2	87.6	.1080
90	-0.055	-0.058	34.0562	27.364	27.369	32.105	36.730	41.248	45.665	71.6	8.57	1449.2	89.4	-.0590
100	-0.422	-0.425	34.1397	27.449	27.453	32.200	36.834	41.362	45.787	63.5	9.29	1447.8	90.9	-.1560
120	-0.303	-0.307	34.1896	27.484	27.488	32.231	36.861	41.385	45.807	60.2	10.56	1448.8	91.4	-.3920
140	0.128	0.122	34.2496	27.510	27.515	32.245	36.863	41.375	45.785	57.8	11.76	1451.2	91.4	-.6120
160	0.697	0.690	34.3460	27.554	27.561	32.272	36.874	41.370	45.767	53.7	12.92	1454.2	91.6	-.7980
180	1.147	1.138	34.4204	27.584	27.592	32.290	36.879	41.363	45.748	51.0	13.99	1456.7	91.7	-.8500
200	1.282	1.272	34.4661	27.612	27.620	32.313	36.898	41.379	45.760	48.6	15.01	1457.7	91.5	-.9050
225	1.357	1.346	34.4987	27.632	27.641	32.332	36.914	41.393	45.772	46.7	16.23	1458.4	91.7	-.8690
250	1.254	1.242	34.5062	27.646	27.654	32.348	36.933	41.414	45.796	45.4	17.39	1458.4	91.7	-.8430
275	1.468	1.455	34.5541	27.669	27.677	32.365	36.944	41.419	45.795	43.5	18.53	1459.8	91.7	-1.027
300	1.593	1.578	34.5800	27.680	27.689	32.373	36.948	41.420	45.793	42.6	19.62	1460.8	91.9	-1.059
325	1.499	1.482	34.5881	27.694	27.703	32.389	36.967	41.441	45.816	41.3	20.68	1460.9	91.7	-1.061
350	1.268	1.250	34.5806	27.704	27.713	32.406	36.990	41.470	45.851	40.2	21.71	1460.2	91.7	-.8920
375	1.302	1.283	34.5925	27.712	27.720	32.412	36.995	41.474	45.854	39.6	22.72	1460.8	91.7	-1.090
400	1.278	1.258	34.5968	27.717	27.725	32.418	37.001	41.481	45.861	39.2	23.71	1461.1	91.8	-1.008
450	1.679	1.655	34.6561	27.735	27.744	32.425	36.997	41.466	45.837	38.1	25.67	1463.8	91.9	-.8970
500	1.557	1.530	34.6556	27.743	27.753	32.437	37.012	41.484	45.858	37.3	27.57	1464.1	91.7	-1.133
550	1.436	1.407	34.6583	27.755	27.764	32.452	37.030	41.505	45.881	36.3	29.44	1464.4	91.7	-.8940
600	1.399	1.367	34.6666	27.764	27.774	32.462	37.041	41.517	45.894	35.5	31.25	1465.1	91.8	-1.217
650	1.484	1.449	34.6853	27.773	27.783	32.470	37.045	41.519	45.894	35.0	33.03	1466.3	92.0	-1.277
700	1.439	1.401	34.6897	27.780	27.790	32.477	37.054	41.529	45.905	34.4	34.77	1467.0	91.8	-.8970
750	1.436	1.396	34.6968	27.785	27.796	32.484	37.060	41.535	45.911	34.0	36.50	1467.8	91.7	-1.272

Table 1.1b

2. Direct krill sampling, Leg I and Leg II; submitted by Valerie Loeb, John Wormuth, Steve Berkowitz and Chul Park.

2.1 Objectives:

The objective of this work was to provide information on the demographic structure, feeding condition and vertical distribution patterns of krill populations in the Elephant Island survey area during both cruise legs and in the predator tracking areas during Leg I. Essential demographic information includes length, reproductive condition, sex ratio, and maturity and moult stages. Feeding condition information includes gut fullness and gut chlorophyll-a/phaeophytin-a concentrations. During each cruise leg, information useful for determining the relationship between krill distribution, population structure and feeding condition, and ambient environmental conditions was derived from standardized bongo net samples taken at each of the 37 CTD/phytoplankton stations within the survey area. Vertically stratified MOCNESS net sampling was performed on acoustically detected krill swarms, with adjustments of depth strata according to observed swarm characteristics.

2.2 Accomplishments:

NET SAMPLING

Three types of nets were used during Leg I (Surveys 1 and 2): non-closing 60cm diameter bongo nets, a 1m^2 MOCNESS, and a MIK net. Only the bongo and MOCNESS nets were used during Leg II (Surveys 3 and 4). The bongos were fitted with 333um and 505um mesh nets, each with a General Oceanics flowmeter mounted in the mouth. They were fished obliquely to a depth of approximately 175m at each of the 37 stations along the hydroacoustic transects around Elephant Island. In addition, 11 oblique bongo tows were made in conjunction with the predator tracking portion of Leg I, eight of which comprised a series taken at 2hr intervals along the track of a fur seal. Additional bongo tows were made during each leg to obtain information on the composition of strong acoustic targets. One of these targeted tows was made during Leg I and three during Leg II.

A total of nine MOCNESS tows were made, six during Leg I and three during Leg II. This instrument carried nine nets of 333um mesh and was used only when large patches of krill were located with the acoustic system and weather conditions permitted deployment. During Leg I, the hauls included replicated vertically stratified samples of acoustically detected layers within the upper 50-60m of the water column. Four of these tows were made to the north and west of Clarence Island and two were made northwest of Seal Island. MOCNESS sampling during Leg II was directed towards assessing acoustics targets within the upper 200m. One 0-200m tow was made northwest of Elephant Island during Survey 3; two tows (one 0-200m, one 0-100m) were made north of the island at the completion of Survey 4. These samples will be used in an analysis of vertical and horizontal structure within large krill aggregations.

Two MIK net tows were made during Leg I. This device is a non-closing net with a

$5m^2$ mouth opening and 2mm mesh. Tows were made northwest of Seal Island and north of Elephant Island to obtain large quantities of krill for demographic analysis.

SHIPBOARD ANALYSES

All krill collected in the 505um mesh bongo net samples were analyzed on board to provide information on the relative abundance, composition and feeding condition of the populations encountered during each acoustic survey and the predator tracking study. During Leg I experimentation was done on the relative value of acetone versus methanol extraction and fresh versus frozen krill in gut chlorophyll-a/phaeophytin-a content analyses; during Leg II evaluations were made of the usefulness of whole krill bodies versus guts in chlorophyll/phaeophytin analyses and of the plant pigment concentrations in the hepatopancreas.

2.3 Disposition of data:

All the krill collected by the 505um mesh bongo nets were analyzed on board and discarded. A representative subsample of the MIK net catch was frozen for onboard analysis and subsequently discarded. The remaining material from the 505um bongo nets, the 333um net samples (or representative subsamples), and entire MOCNESS samples were preserved in formalin; all but the 505um samples were sent to Dr. John Wormuth (Texas A&M University) for complete analysis, the 505um samples were sent to the Southwest Fisheries Center, La Jolla.

2.4 Tentative Conclusions:

Krill Populations Sampled During Survey 1, 6-11 January.

Krill were collected by eight of 19 bongo net tows made in conjunction with CTD/rosette casts during Survey 1. Overall abundances were low, ranging from 2-34 krill per positive tow. The mean abundance estimate was 1.2 (± 2.0) krill/m^2. Although the largest catch was at Station 2 northwest of Elephant Island, catch frequency and abundance were generally higher at stations to the east of the island (Stations 16, 18 and 19; Figure 2.1) than in other areas.

The majority of the individuals collected were reproductively mature. No juvenile forms were taken and only one of the 38 females and 10 of the 55 males (18%) were immature. The mature forms appeared to be reproductively active, with 71% of the males having fully developed petasmae and spermatophores and 71% of the females bearing spermatophores. None of the females were gravid. Sizes ranged from 32-54mm standard length (Figure 2.2) with a mean length of 42mm (± 6mm). Females exhibited abundance maxima at 36-39mm (50%) and 42-43mm (18%); males had abundance maxima at 37-44mm (47%) and 52mm (12%).

With two exceptions, the populations sampled had been recently feeding. Stomachs were generally >75% full for all individuals collected at each station. However, the krill collected at Station 18 averaged only 50% gut fullness, and the individuals collected at

Station 2 all had empty stomachs. Insufficient quantities of krill were captured at each station to perform chlorophyll-a analyses.

Krill Populations Sampled During Survey 2, 21-26 January.

Although the frequency of occurrence was lower (five of 18 stations), larger numbers of krill were collected during Survey 2 (157 versus 93) and the overall mean abundance estimate 2.7 (± 5.9) krill/m^2 was twice that of Survey 1. Positive tows contained 5-84 individuals. Largest catches occurred to the northeast of Elephant Island (Stations 20 and 25) and between Elephant and Clarence Islands (Station 31; Figure 2.3).

Males dominated the total catch (64%) with equal representation of immature and mature forms. Only one juvenile was caught. The females were all reproductively mature, with 15 of the 44 individuals (34%) demonstrating ovarian development; one female had recently spawned. The size range (31-52mm) and mean length (41 ± 6mm) were similar to Survey 1 (Figure 2.4). Females demonstrated abundance peaks at 35mm (11%) and 38-39mm (36%) and had an overall size frequency distribution almost identical to that of Survey 1. Mature males had abundance peaks at 42-43mm and 45-46mm (22% in both cases). The relatively large numbers of immature males collected during Survey 2 ranged from 32-47mm in length with abundance peaks at 38-41mm (45%). Almost all of these large juveniles were from Station 31 and may represent the presence of Weddell Sea populations in the area between Elephant and Clarence Islands.

Gut fullness was generally lower than during Survey 1, with mean values between 25 and 50% for all but Station 31 where it was >75%.

Krill Populations Sampled During Survey 3, 7-13 February:

Krill were collected at nine of 19 stations sampled during Survey 3. Overall abundances (1-8 krill per positive tow) were lower than those encountered during Surveys 1 and 2. Only 31 krill were collected in the combined survey samples and the mean abundance estimate of 0.6 (± 0.9) krill/m^2 was half that of the lowest (Survey 1) value of Leg I. Largest survey abundance estimates (2-3 krill/m^2) occurred at Stations 3 to the southwest and 15 and 19 to the northeast of Elephant Island (Figure 2.5). Greater catches (5-7 krill/m^2) occurred in targeted bongo net tows taken at Stations X-2 and X-3 adjacent to survey Station 19.

Almost all of the individuals collected were reproductively mature. No juvenile forms were taken and only one of the 19 males was immature. All but one of the 12 females bore spermatophores; five of these had developing ovaries and one was gravid. Sizes ranged from 38-52mm standard length (Figure 2.6) with a mean length of 44mm (± 4mm). Females exhibited abundance maxima at 41-44mm (58%); males had abundance maxima at 42-45mm (53%). Mean gut fullness was >50% all nine stations.

The acoustic targets sampled at Stations X-2 and X-3 comprised two layers, one located primarily at ca. 100-150m the other at ca. 30-50m. The krill collected within those depth intervals had size distributions similar to one another (means 43mm and 44mm, respectively) and to the overall survey. However, the sex ratios differed between the two tows: females dominated the deeper catch (68%) while males were more abundant in the shallower catch (70%).

Krill Populations Sampled During Survey 4, 21-27 February.

The frequency of krill in samples was lower (five of 18 stations) during Survey 4 as compared to Survey 3, but larger numbers of krill were collected (97 total) and the overall mean abundance estimate 1.8 (± 4.9) krill/m^2 was three times greater. This catch size was most similar to that of Survey 1. As with Survey 2, largest numbers of krill occurred to the northeast of Elephant Island (Station 25) and between Elephant and Clarence Islands (Station 31; Figure 2.7).

No juvenile forms were caught, and females and males were fairly equally represented (45 versus 52). All but two of the females were reproductively mature: five (11%) demonstrated ovarian development; 30 (75%) were gravid; and three others (7%) had recently spawned. Most of the males (80%) were reproductively mature. The overall size range (37-53mm) and mean length (44 ± 3mm) were similar to those observed during Survey 3. Female and male size distributions were similar (Figure 2.8) with females demonstrating abundance peaks at 42-44mm (45%) and males at 41-43mm (46%). Gut fullness was generally between 50 and 75% for individuals in all samples except for Station 31 where it was generally >75%.

A total of 102 krill were collected in the targeted tow at Station X-4 adjacent to Station 25. This sample was dominated by females (73%). The reproductive composition and size distribution represented in this sample were very similar to those of the overall survey area.

Guts were removed from krill collected during Surveys 2, 3, and 4 for chlorophyll-a and phaeophytin-a analyses, but the final results of those analyses are not available at this time.

Overview of AMLR 1990 Cruise Results

The overall krill abundance estimate based on bongo samples collected during the four surveys (1.6 krill/m^2) was half that obtained during the January-February 1988 AMLR Elephant Island surveys (3.8 krill/m^2). Both of these survey values were low compared to March 1981 and 1984 bongo surveys in the Elephant Island area (38 and 30 krill/m^2, respectively). The relatively low values in the AMLR surveys could in part result from predominantly daylight conditions during the January-February sampling periods and related increased net avoidance. The low 1990 values could also be in part due to the virtual absence of juveniles and the low numbers of immature forms. Juvenile and immature forms contributed 36% of the krill caught in 1988; their low contribution to the 1990 samples could account for much of the between year abundance difference. The predominance of larger, mature individuals in 1990 (mean length 42-44mm versus 40mm in 1988) could also have associated enhanced net avoidance and undersampling.

The absence of juveniles is interesting but not surprising since few larvae were collected in 1989 AMLR samples. This suggests minimal year class strength from that year.

The krill demonstrated a fairly stable distribution pattern over the two month sampling period, with highest abundance generally occurring to the north and east of Elephant Island. With the exception of an input of large immature forms of possibly Weddell Sea origin at Station 31, the population structure was rather uniform, suggesting a limited faunal source. Over the sampling period there was a transition from reproductively active populations during mid January to gravid and spent females in late February. The predominance of reproductively mature males and gravid females within the adult populations was also observed in the January-February 1988 samples.

2.5 Problems, Suggestions and Recommendations:

Continuation of routine standard net tows in conjunction with the CTD/rosette casts during the acoustic surveys is strongly recommended. These non-targeted tows provide material to evaluate the general population structure and may indicate interesting features such as population mixing and initiation of swarm formation which may prove valuable for later directed studies. Such survey tows would provide a greater amount of information if regularly done with the MOCNESS. This could be implemented if the MOCNESS were maintained on the main deck and if it and the CTD were operated by separate conductivity cables and winches.

Given the Elephant Island survey area established this year, the net sampling grid is rather coarse and would greatly benefit from closer spacing should time be available. The results of the net collections made during the predator tracking studies have not been treated here, but such sampling should be included in future studies to augment the survey data and to provide information on potential prey populations.

The SeaMac winch proved unreliable and not powerful enough to recover the MIK net at normal towing speeds. The winch with conducting cable was generally satisfactory for MOCNESS use; however, it was not capable of recovering this gear at ship speeds above ca. 5-6kt, which are feasible with the use of the depressor vane on the MOCNESS frame. Winch capacities need to be examined as future cruises are planned.

The addition of a Doppler speed log or other comparable device to the *Surveyor's* equipment complement would greatly facilitate towing nets in a consistent manner. The GPS system does not appear to be sufficient for this purpose.

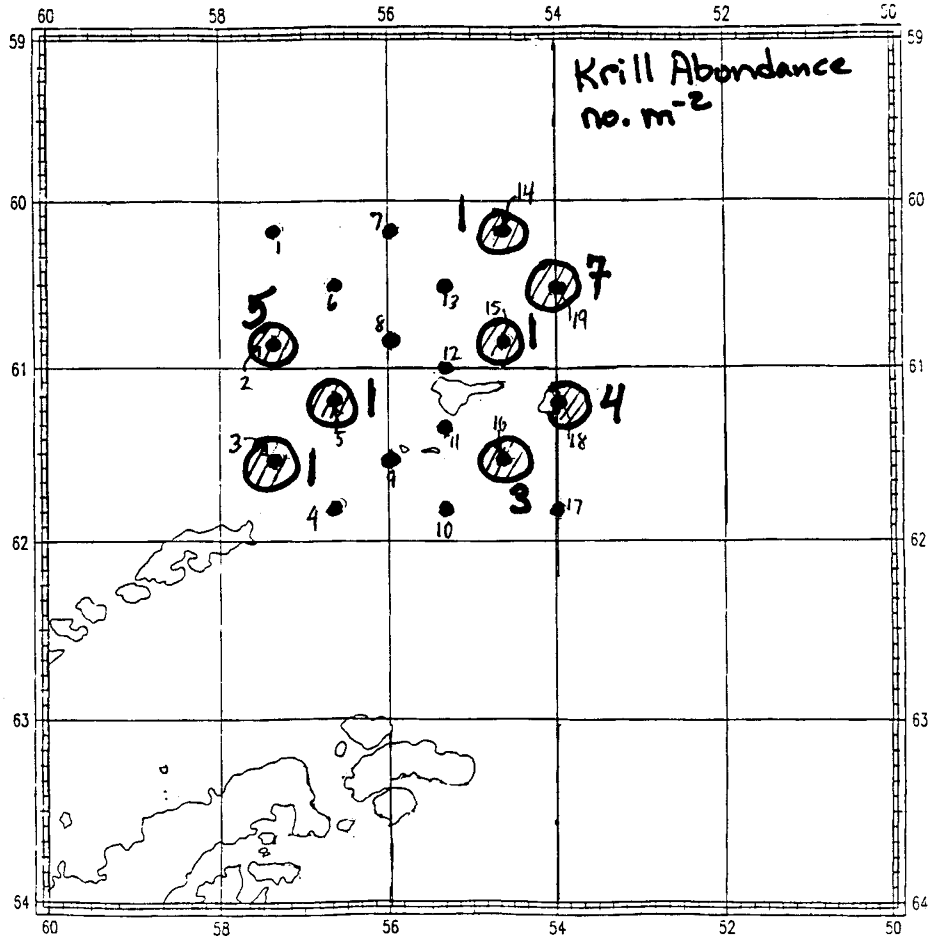


Figure 2.1. Distribution of krill catches for first survey.

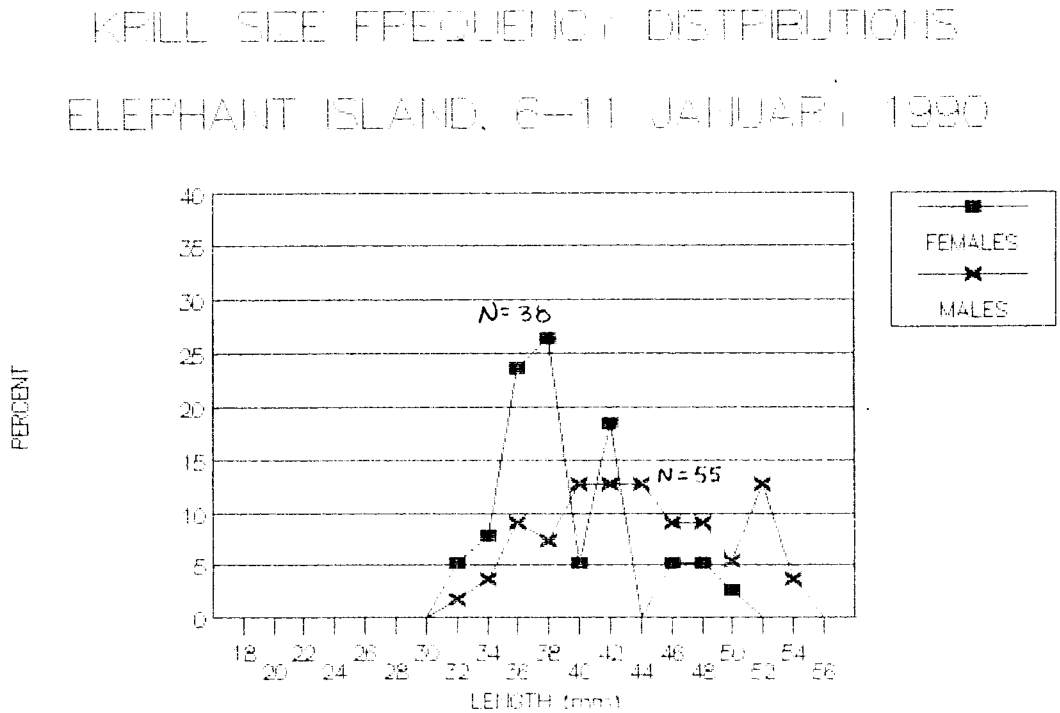


Figure 2.2 Krill size frequency distributions for first survey.

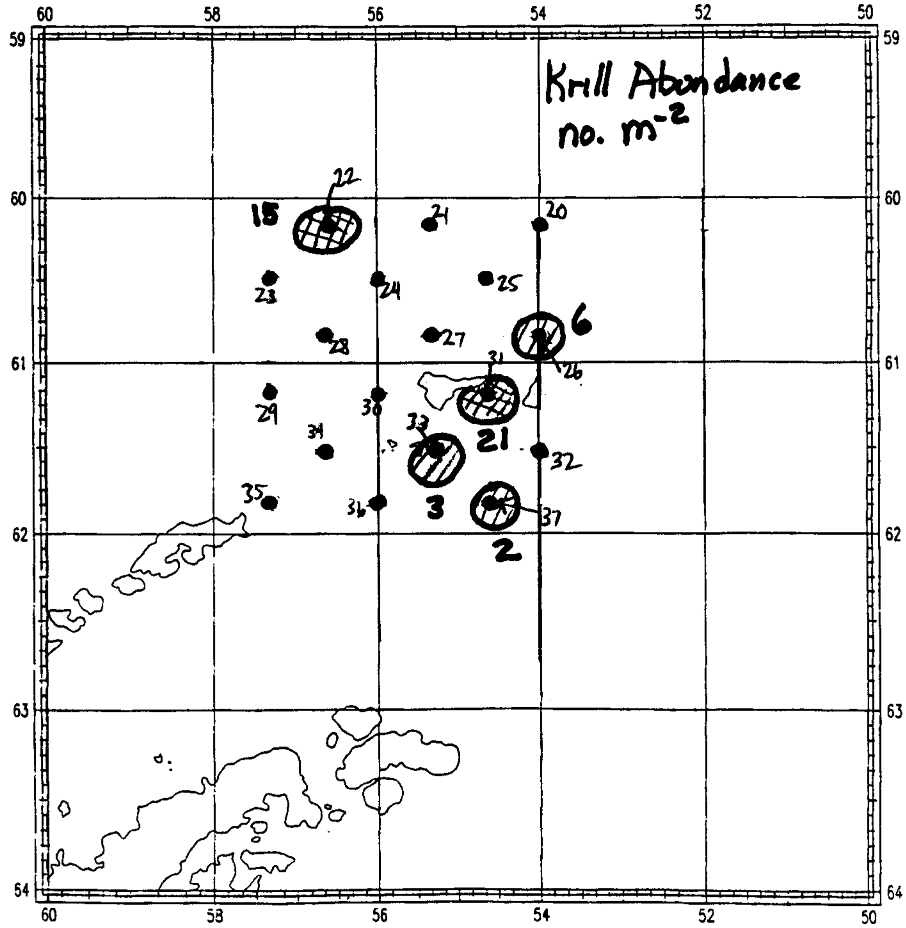


Figure 2.3. Distribution of krill catches for second survey.

KRILL SIZE FREQUENCY DISTRIBUTIONS

ELEPHANT ISLAND, 21–26 JANUARY 1990

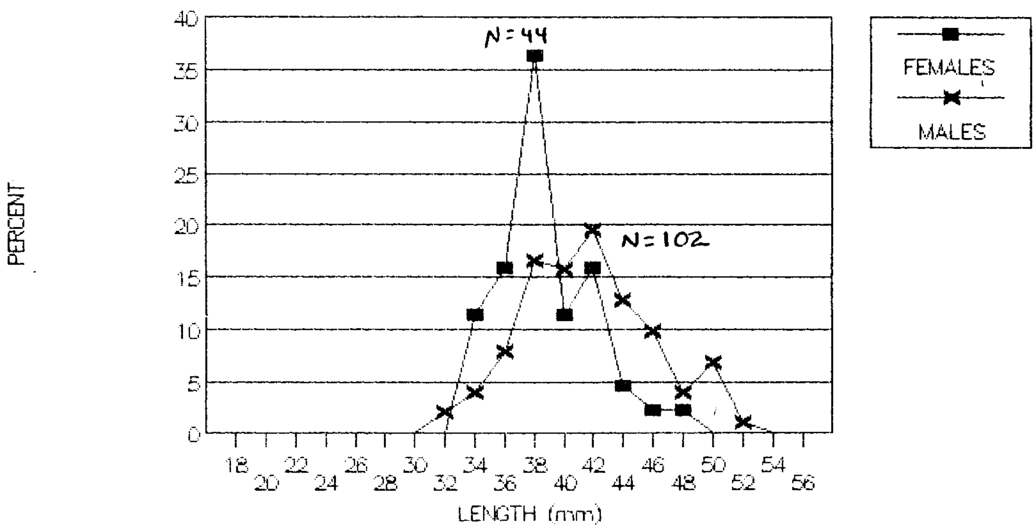


Figure 2.4. Krill size frequency distributions for second survey.

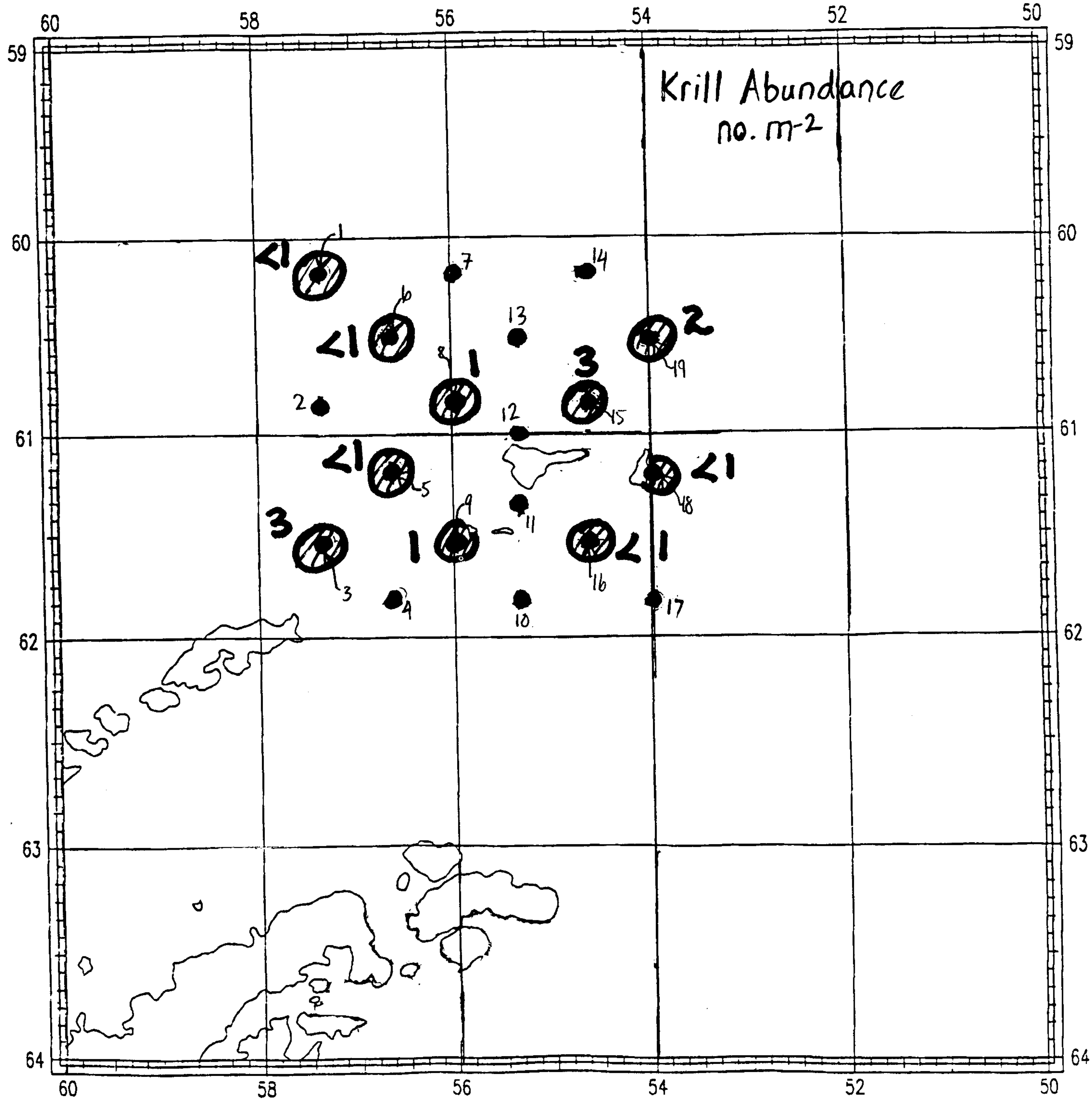


Figure 2.5 Distribution of krill catches for Survey 3.

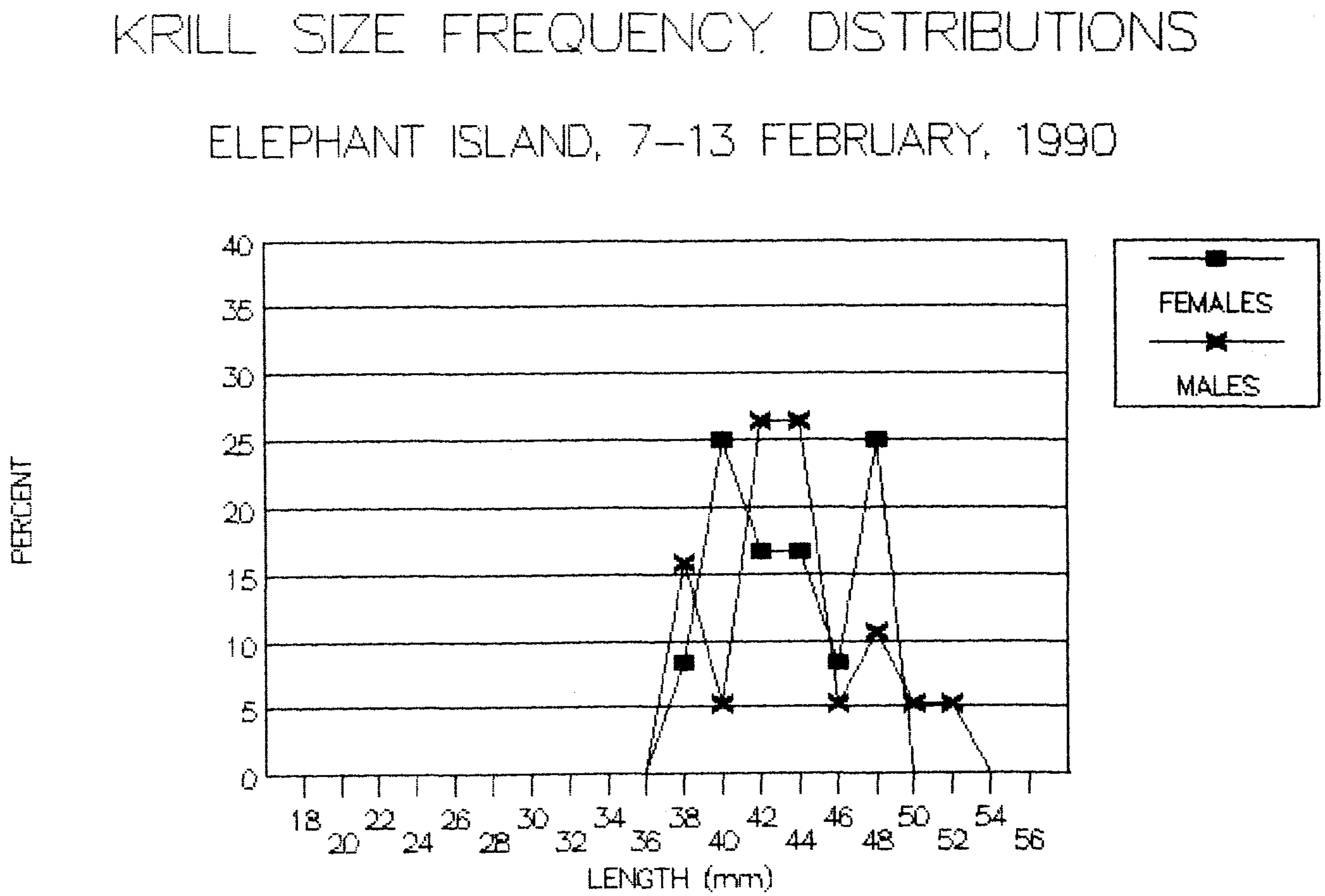


Figure 2.6 Krill size frequency distributions for Survey 3.

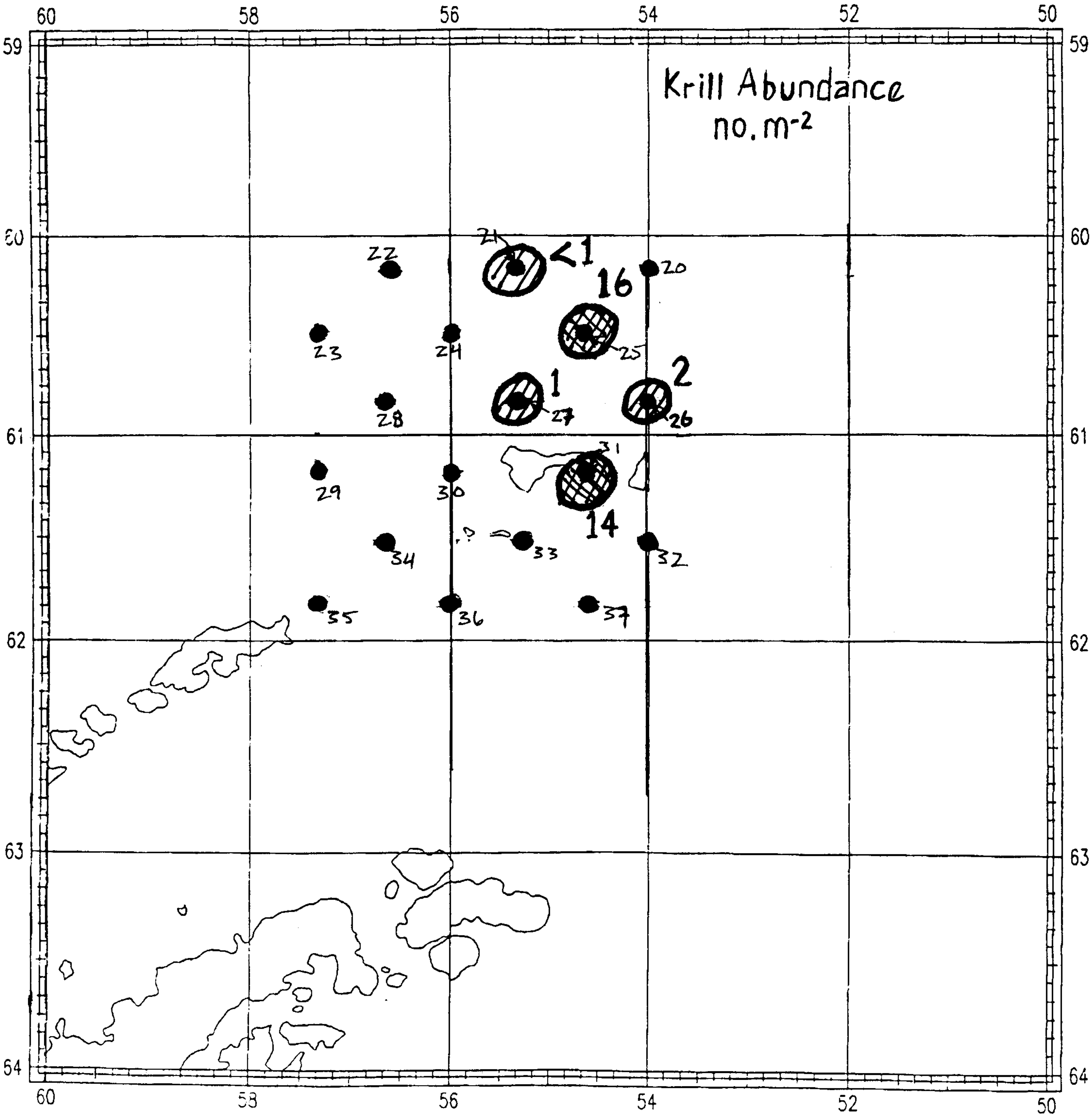


Figure 2.7 Distribution of krill catches for Survey 4.

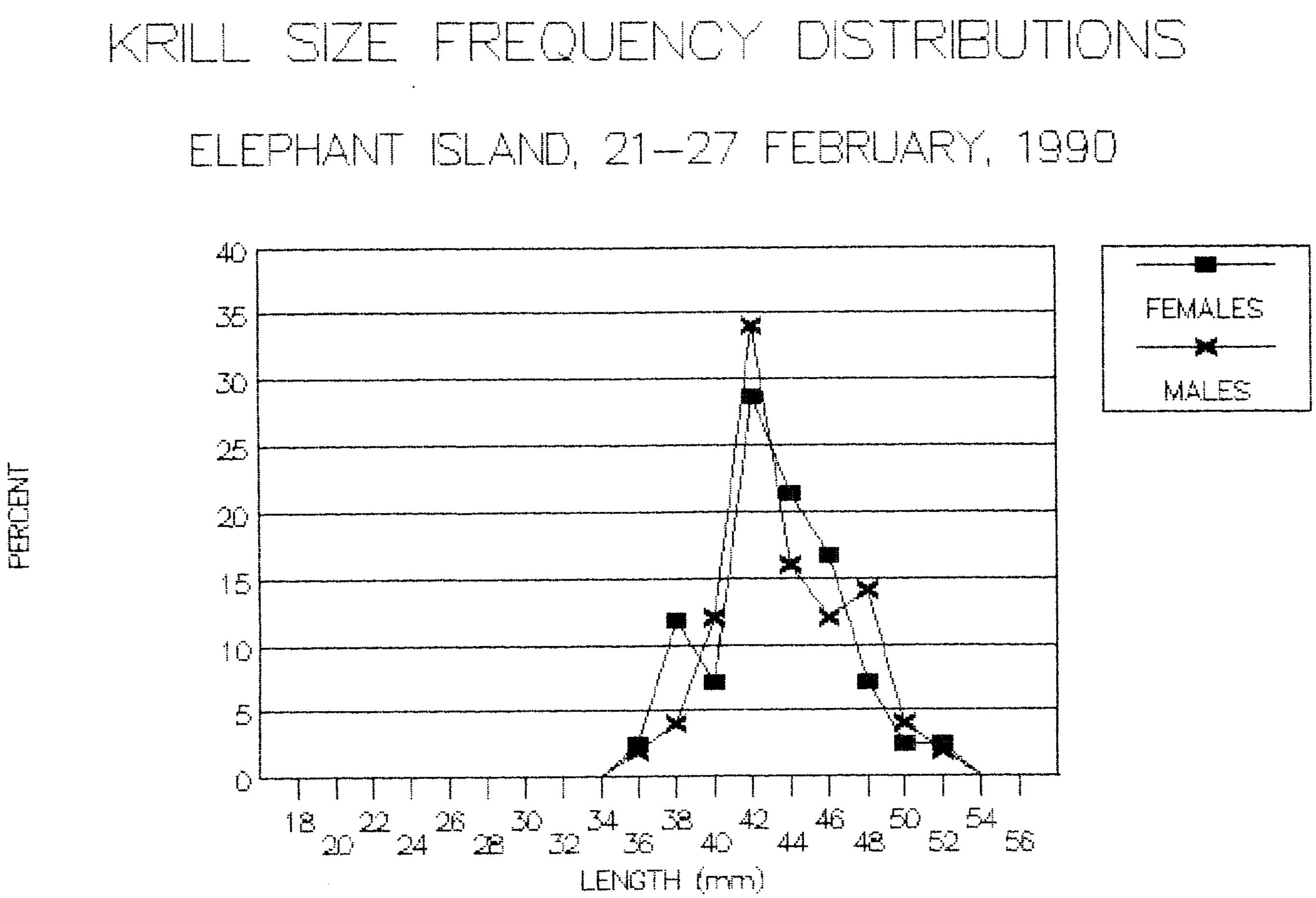


Figure 2.8 Krill size frequency distributions for Survey 4.

3. Hydroacoustic survey for prey organisms; Leg I, submitted by Michael Macaulay and Adrian Madriolas; Leg II, submitted by Kendra Daly and Patricia Morrison.

3.1 Objectives:

The research involved a quantitative hydroacoustic survey of the population of krill (*Euphausia superba*) and other targets in the immediate vicinity of Elephant Island. The primary objective was to describe the distribution and abundance of concentrations of acoustically detectable targets. This survey will provide data comparable only to that resulting from the 1987-1989 AMLR surveys of the Elephant Island area.

3.2 Accomplishments:

Both of the survey grids were completed on each leg. 120 kHz and 200 kHz signals were recorded digitally for a total of 531 hours (Leg I, 270 hours; Leg II, 261 hours) of recorded quantitative data for use in subsequent analyses. The sampling depths were from 6-10m below the surface to 250m or bottom whichever occurred first. The 200 kHz signal was completely analyzed in real-time to acoustic biomass/m^2 for each minute along the trackline, using an assumed value for the target strength. The results of the analyses were made available on a daily basis. While the analyses were being performed, a real-time display of the vertical and horizontal distribution of the abundance of prey was available for inspection. This display facilitated selection of sampling sites for deployment of bongo, MOCNESS and MIK nets to obtain samples of prey and other organisms. The final analyses for each of the four surveys are presented in Tables 3.1-3.4 and Figures 3.1-3.12. The tables show the distribution of biomass by block of area within the total survey area and the figures show the cruise tracks and contour plots for all the surveys. Only limited further refinements of the analyses conducted in the field will be done in Seattle, mostly to provide plots and graphs of aspects of the results of the completed analyses. The digital tapes should be analyzed for more detail.

In addition to the survey grids, data also were collected and analyzed for the time spent tracking seals and penguins from Seal Island on Leg I and for horizontal MOCNESS tows which sampled layers of acoustic targets on both cruises. The tracking study data was not originally proposed to be analyzed but it was found to be convenient to do so in real time. Not all the tracking study data were digitally recorded, but all the 200 kHz data were analyzed to the level of integrated biomass by depth and time. Color echogram summaries of the distribution of prey and numerical files of these distributions were prepared for J. Bengtson. Color echograms of MOCNESS tows also were made for J. Wormuth and contour plots of the surveys were given to Philip Hamilton, as requested.

Acoustic surveys generate a large amount of data. For example from Leg I, there are approximately 15 megabytes of data from Survey 1, 19 megabytes from the tracking studies and 20 megabytes from Survey 2 for a total of 54 megabytes. This would be approximately 150 megabytes of data if the files were turned into ASCII data.

3.3 Disposition of Data:

The hydroacoustic sampling was done with two frequencies, 120 kHz and 200 kHz. These two frequencies have been used on each of the AMLR cruises to date. The method of data analysis is echo integration. This method requires the periodic sampling of the ensonified population for determination of length-frequency. The length-frequency data are used to calculate target-strength from established equations. The resulting target-strength is then used to convert measurements of volume scattered sound into estimates of biomass. The methods used, both hardware and software, are the same as have been used in previous cruises. The distribution of biomass along the trackline was contoured using a commercial software package. The contouring is done using a Kriging method and involves using a least squares fit to the trends in the data. The results of the contouring of the distributions is shown in Figures 3.1-3.12. The contour interval in these figures is 50 tons per nm squared beginning at 50 tons per nm squared and extending to the maximum value obtained. Blocks of area used to calculate biomass are indicated on Figures 3.1 and 3.4. These areas are designated "A" through "D" in an west-to-east direction and "1" through "4" in a north-to-south direction (eg. the northwest corner is block A1 and the southeast corner is D4). The acoustic data are recorded in digital format so that other quantitative post-cruise analysis might be performed. The resulting files of analyzed data will be made available to other investigators in the form of MS-DOS format ASCII files. All data are available from Dr. Michael Macaulay, University of Washington.

3.4 Tentative conclusions:

The biomass of krill in the survey area was less than last year (1989) and no large "super-swarm" was observed. A large increase in abundance was observed between Surveys 1 and 2 (see Table 3.1 and Table 3.2). Abundance declined during Survey 3 and increased again during Survey 4 (Tables 3.3 and 3.4). These changes could have resulted from cyclic immigration and emigration of krill from the survey area or from variations in the krill distribution relative to the tracklines. Survey 1 and 3 followed north-south tracklines while tracklines for Survey 2 and 4 were east-west. Considerable movement in the distribution of biomass also was observed within the study area (Figures 3.1-3.12). However, the densest concentrations to the N and NE of Elephant Island persisted during the last three surveys. The changes in distribution, as illustrated by the contour plots, suggest that possible sources of immigrant individuals and patches of krill may be from the King George Island direction and the South Orkney Islands direction (contrast Figures 3.1-3.3 with Figures 3.4-3.6, the concentrations eastward and westward from Elephant Island were larger in Survey 2 than was present in the first). Additional analyses will be completed investigating krill biomass in the study area.

It was clear from the real-time display of distribution made during the tracking studies on Leg I, that seals and penguins were not concentrating on the highest krill concentrations available to them. These tagged individuals, in fact, consistently passed over a large concentration and foraged in the lower concentrations beyond. This raises the possibility that foraging success for seals and penguins may be better when prey are in lower concentrations than in higher ones. Net sampling also has been observed to be more successful under low density conditions. The predator-avoidance capability of individual krill increases dramatically in swarms where inter-individual communication results in a rapid response to disturbances.

3.5 Problems, Suggestions and Recommendations:

The *Surveyor* performed well as a hydroacoustics platform; however, the limited ability to obtain large samples of prey from any site will not permit estimation of target-strength as more than a generalized mean for the entire area sampled. This mean can be calculated as a pooled mean of all the net samples. Damage to the towed fin occurred as a result of having to constantly deploy and retrieve the V-fin in order to complete CTD stations. Since no spare fin was available, the damaged fin was repaired by the ship's Deck and Engineering departments, and their assistance is gratefully acknowledged. More extensive damage to the fin could have terminated the hydroacoustic survey. A spare V-fin should be available during subsequent cruises. The use of the winch system designed to be used with this V-fin would have also prevented this damage from occurring. The limited size of the survey area prevents resolution of the source of krill populations migrating into the survey area and prevents making more than cursory comparisons of this years survey data to the 1987-1989 AMLR survey data.

FIGURE CAPTIONS

Figure 3.1 AMLR 1990 Survey 1 cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.

Figure 3.2 AMLR 1990 Survey 1 stacked contour plot of the biomass distribution observed along the cruise track.

Figure 3.3 AMLR 1990 Survey 1 contour plot of the biomass distribution.

Figure 3.4 AMLR 1990 Survey 2 cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.

Figure 3.5 AMLR 1990 Survey 2 stacked contour plot of the biomass distribution observed along the cruise track.

Figure 3.6 AMLR 1990 Survey 2 contour plot of the biomass distribution.

Figure 3.7 AMLR 1990 Survey 3 cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.

Figure 3.8 AMLR 1990 Survey 3 stacked contour plot of the biomass distribution observed along the cruise track.

Figure 3.9 AMLR 1990 Survey 3 contour plot of the biomass distribution.

Figure 3.10 AMLR 1990 Survey 4 cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.

Figure 3.11 AMLR 1990 Survey 4 stacked contour plot of the biomass distribution observed along the cruise track.

Figure 3.12 AMLR 1990 Survey 4 contour plot of the biomass distribution.

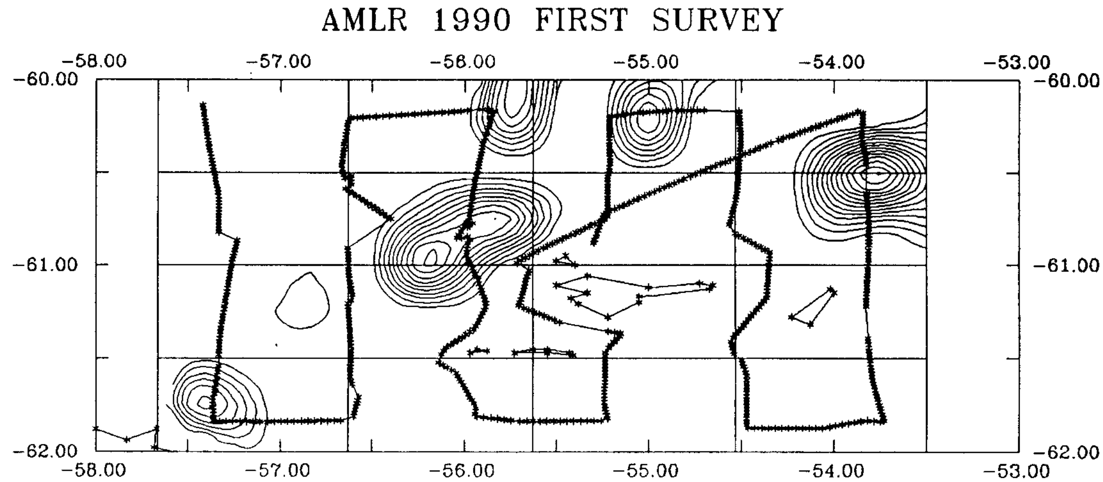


Figure 3.1 AMLR 1990 Survey 1 Cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.

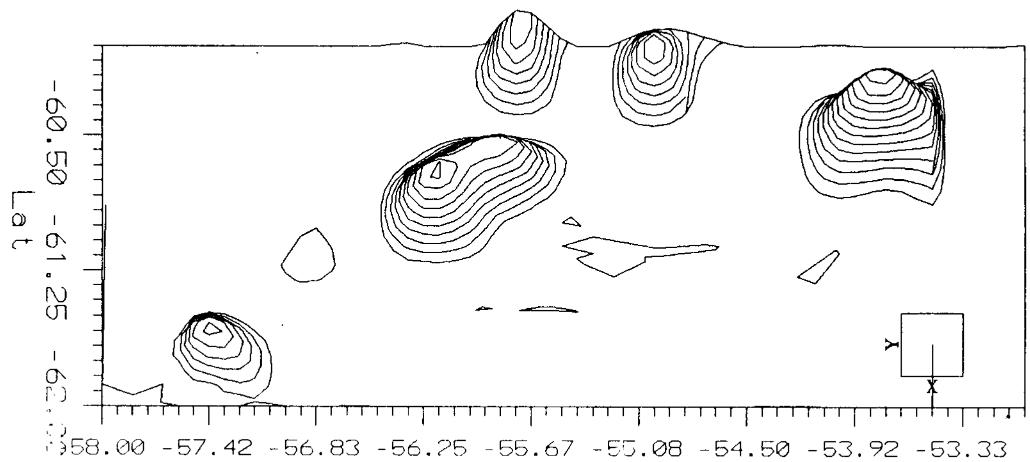


Figure 3.2 AMLR 1990 Survey 1 stacked contour plot of the biomass distribution observed along the cruise track.

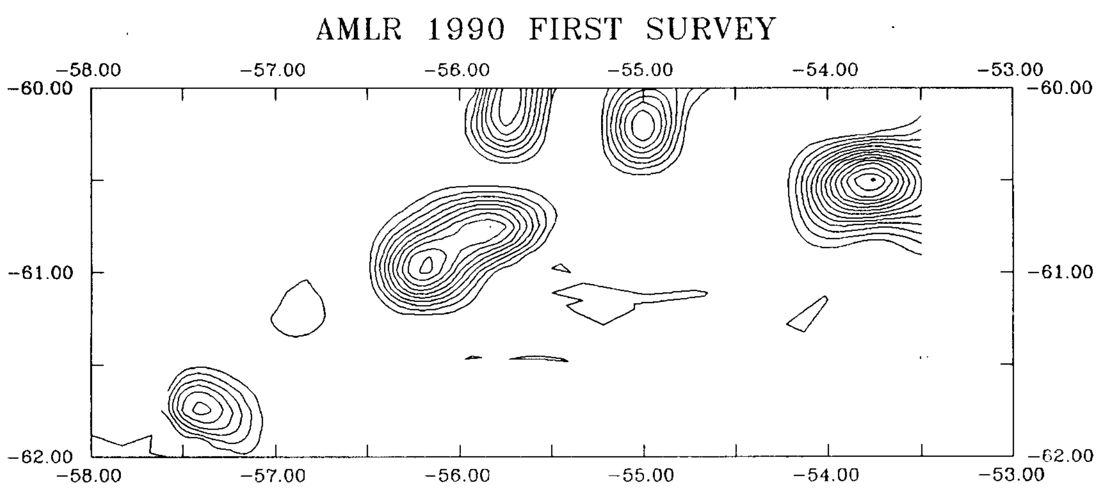


Figure 3.3 AMLR 1990 Survey 1 contour plot of the biomass distribution.

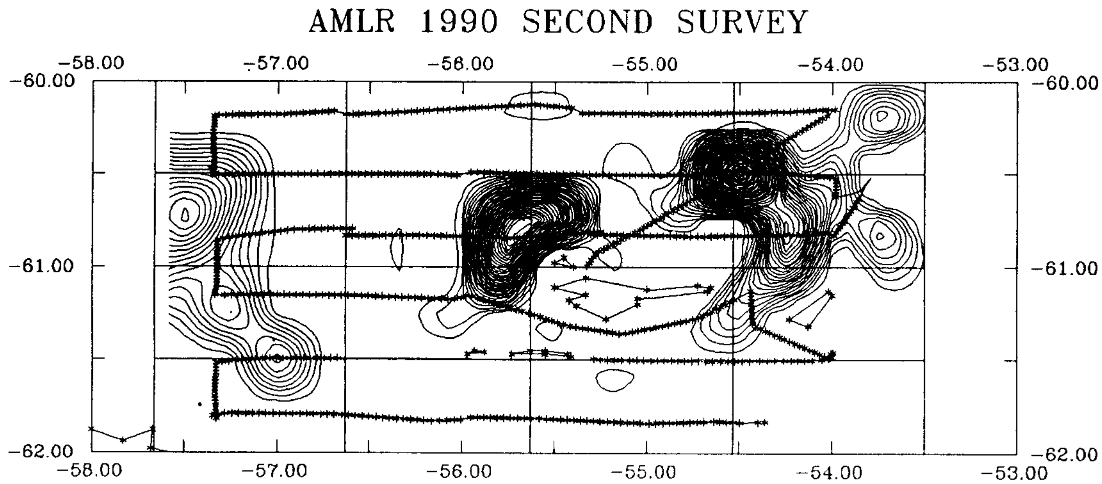


Figure 3.4 AMLR 1990 Survey 2 Cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.

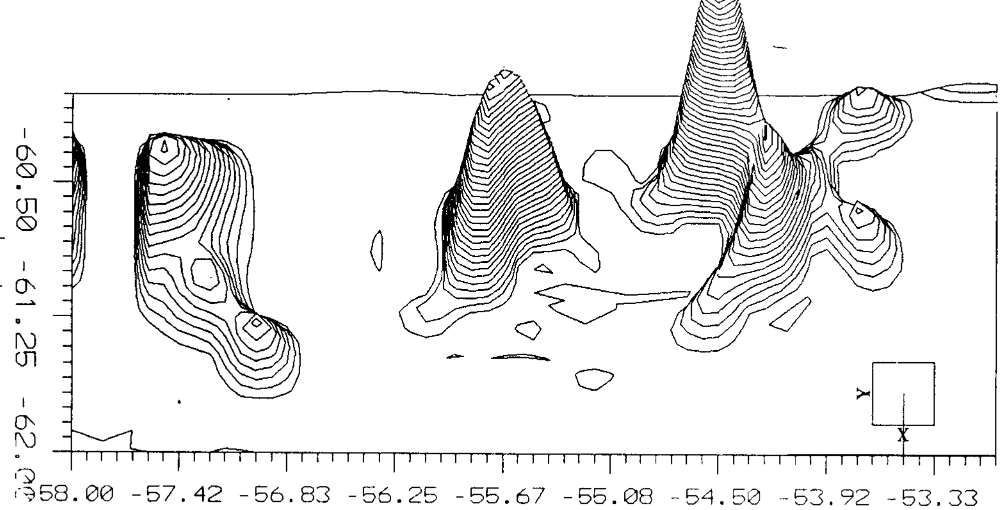


Figure 3.5. AMLR 1990 Survey 2 stacked contour plot of the biomass distribution observed along the cruise track.

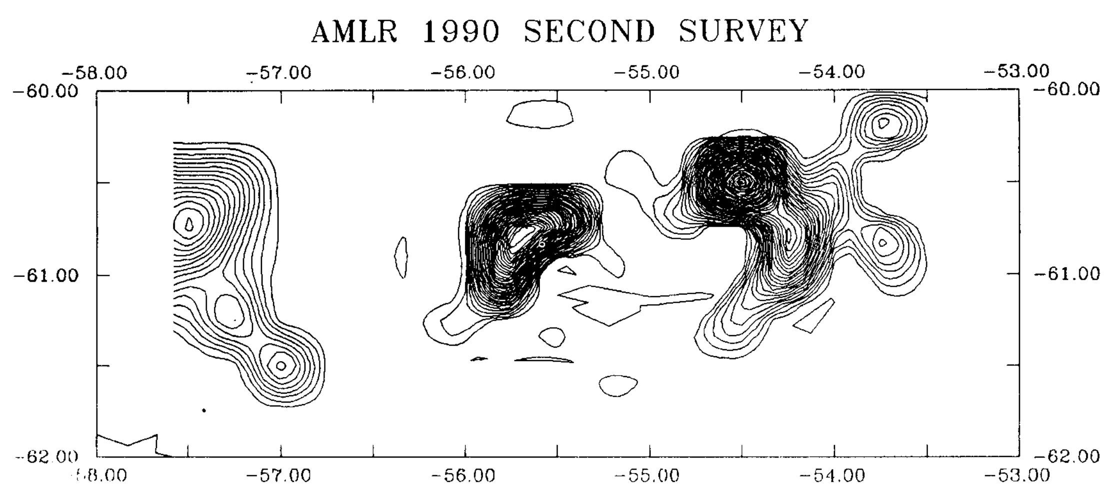
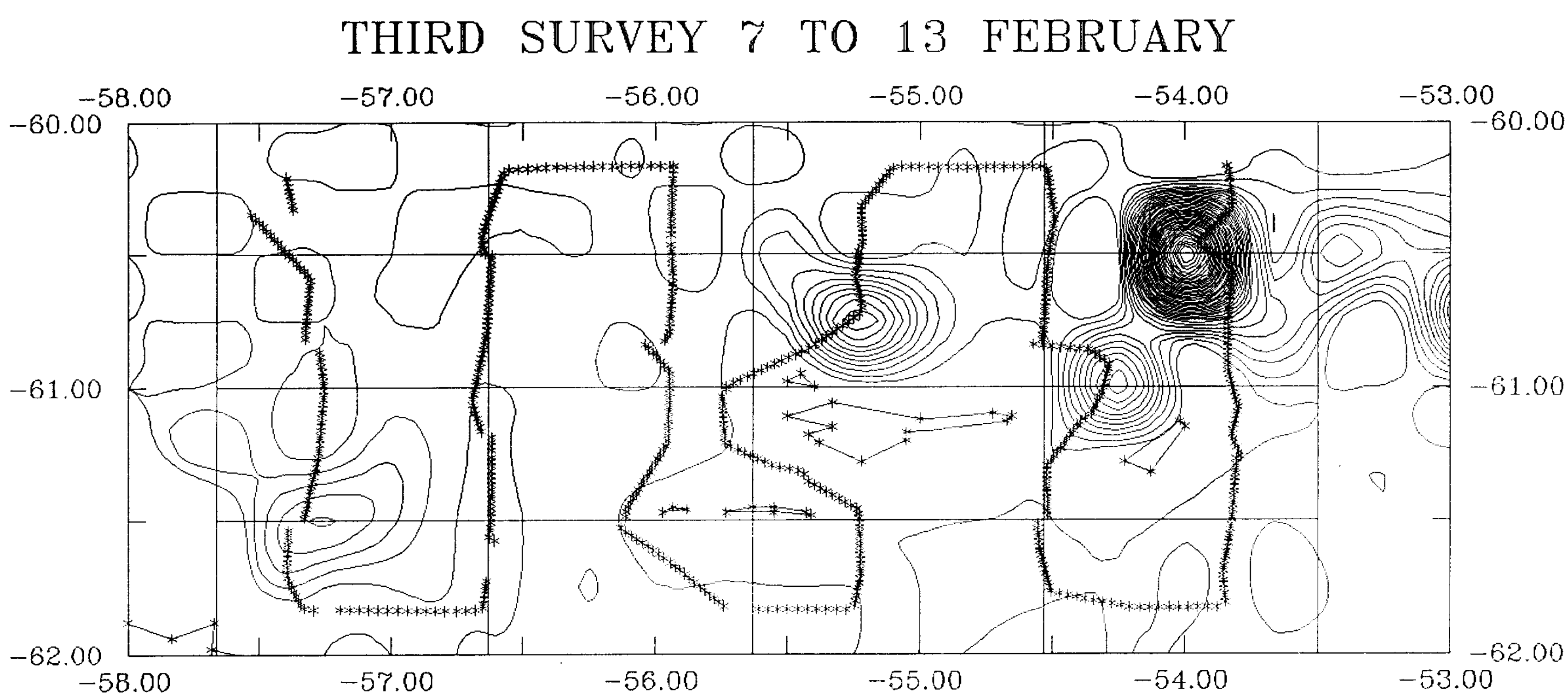


Figure 3.6 AMLR 1990 Survey 2 contour plot of the biomass distribution.

Figure 3.7 AMLR 1990 Survey 3 cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.



THIRD SURVEY 7 TO 13 FEBRUARY

Figure 3.8 AMLR 1990 Survey 3 stacked contour plot of the biomass distribution observed along the cruise track.

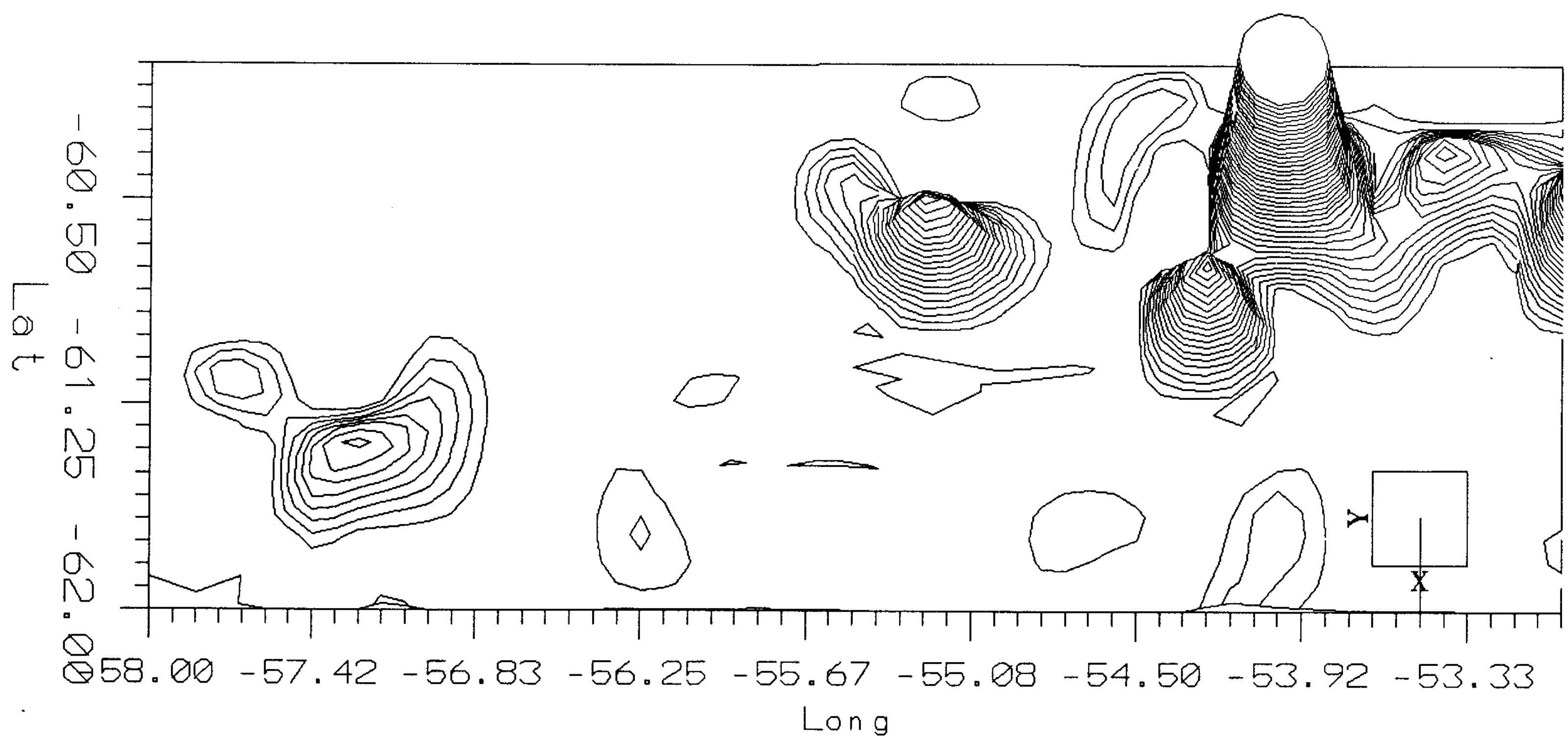


Figure 3.9 AMLR 1990 Survey 3 contour plot of the biomass distribution.

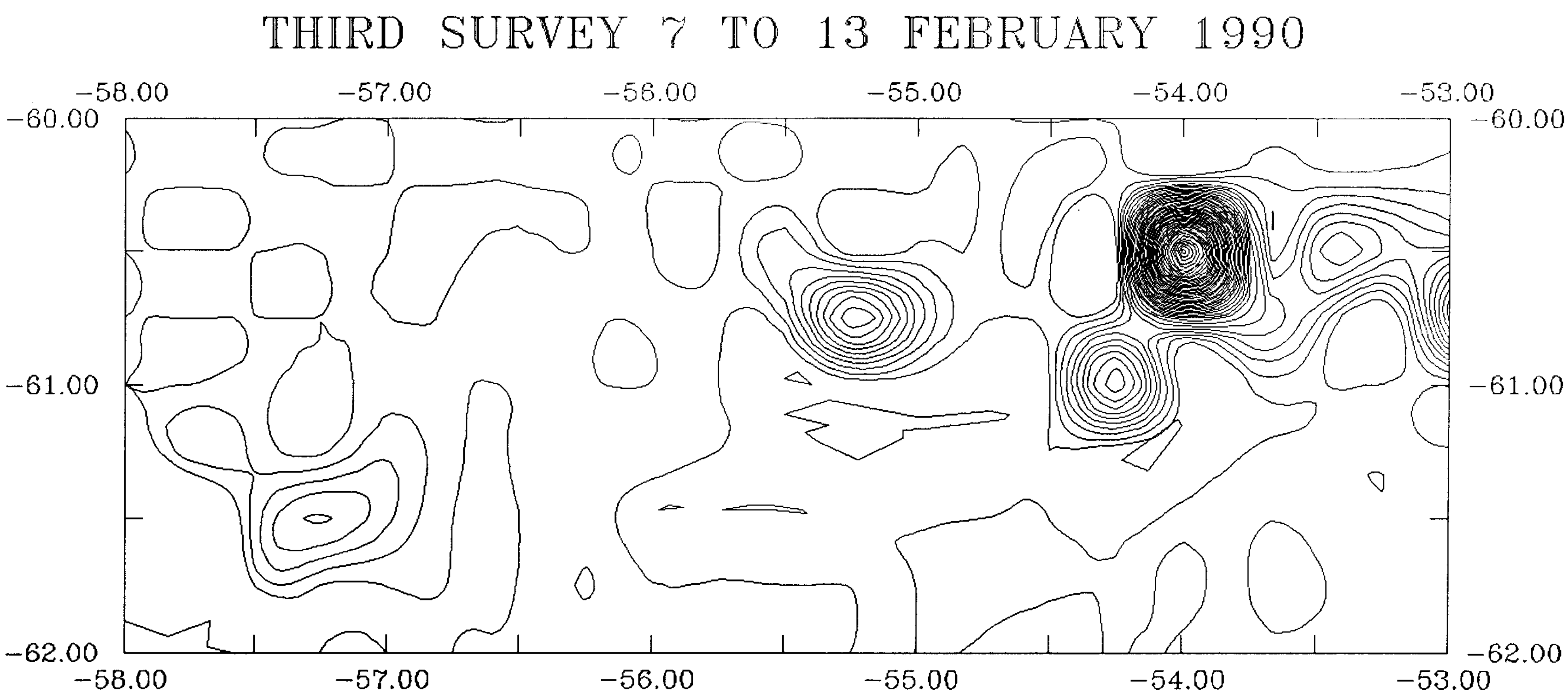
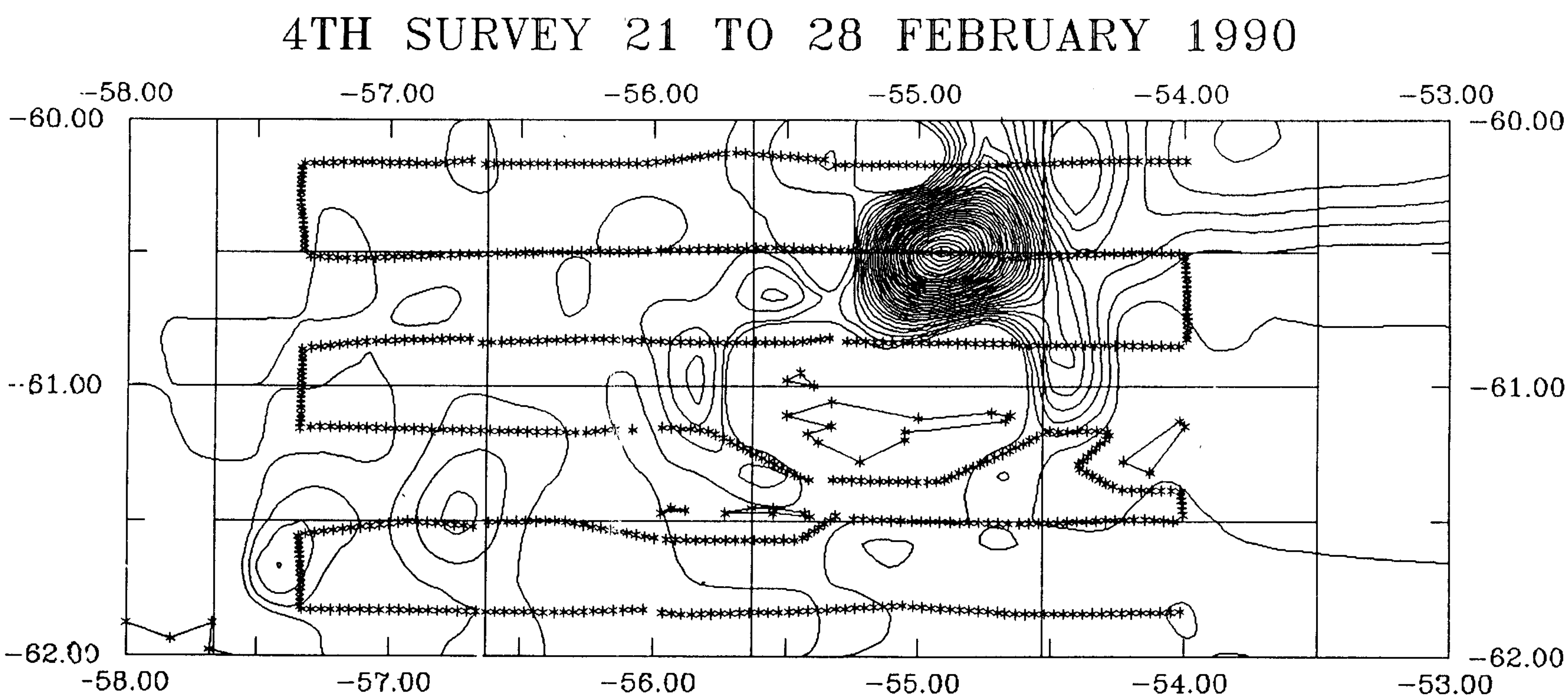


Figure 3.10 AMLR 1990 Survey 4 cruise track, boundaries of the blocks of area used for biomass calculation and distribution of biomass.



4TH SURVEY 21 TO 28 FEBRUARY 1990

Figure 3.11 AMLR 1990 Survey 4 stacked contour plot of the biomass distribution observed along the cruise track.

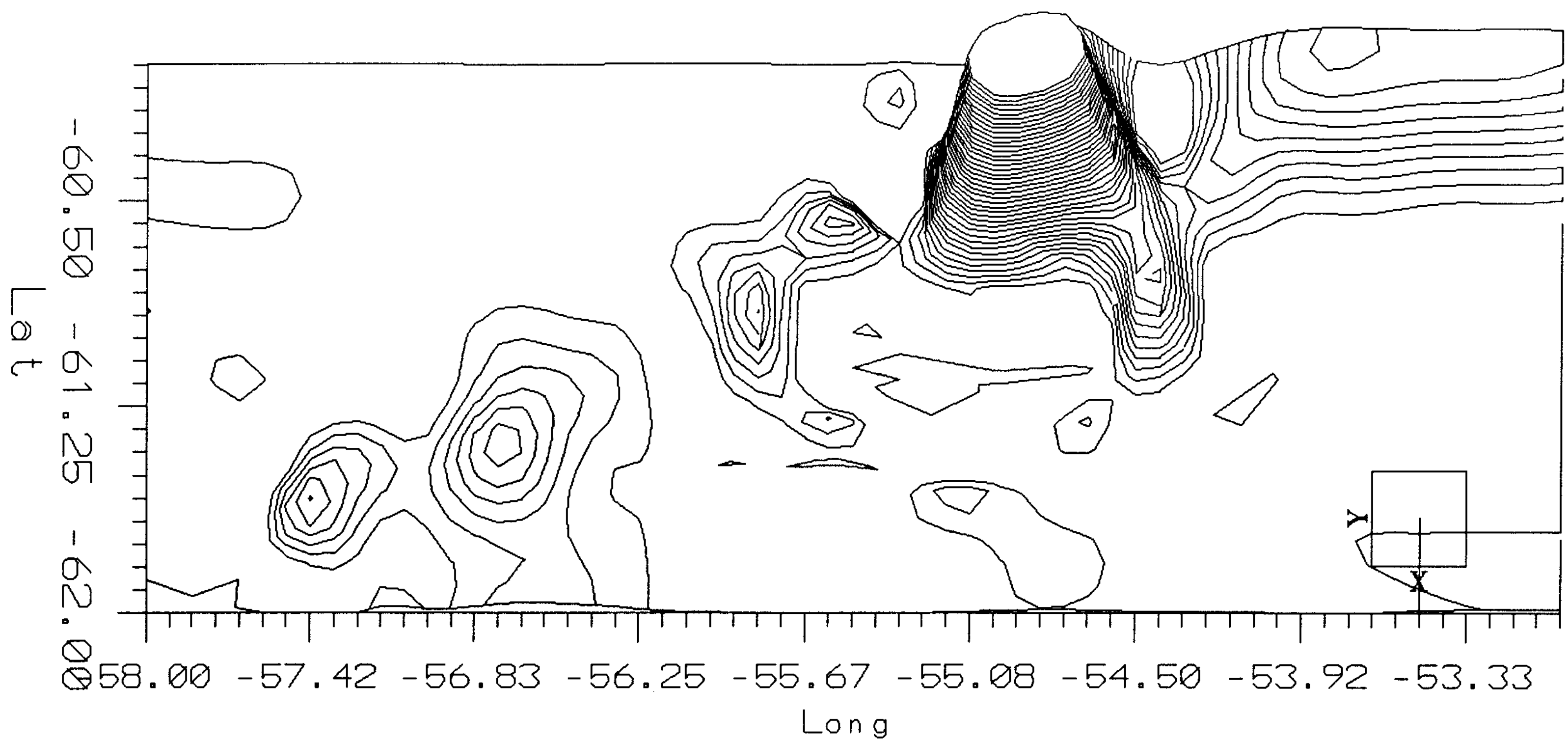


Figure 3.12 AMLR 1990 Survey 4 contour plot of the biomass distribution.

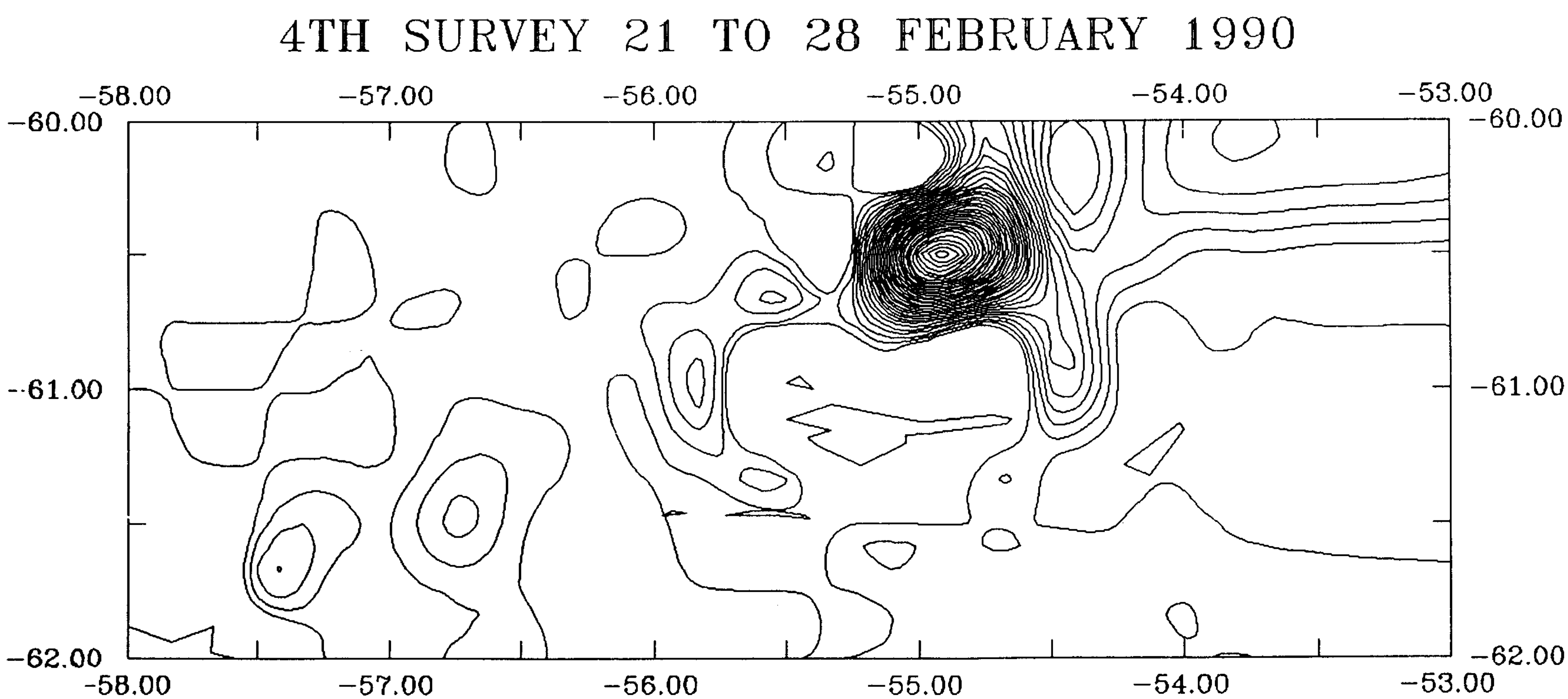


TABLE 3.1 Biomass by block at Elephant Island during AMLR 1990 Survey 1.

BOX	DIST NM	AREA NM**2	XBAR T/NM**2	B T	RANGE T	
A1	21.710	600.000	.10	62.6	-70.0	190.0
A2	28.300	600.000	8.91	5347.1	-1200.0	11890.0
A3	28.690	600.000	31.18	18711.0	-3350.0	40770.0
A4	39.090	675.000	43.20	29158.0	-7600.0	65920.0
B1	59.360	675.000	21.45	14480.0	-2880.0	31840.0
B2	61.440	900.000	260.32	234290.0	109820.0	358750.0
B3	80.010	900.000	4.96	4463.2	1450.0	7460.0
B4	45.230	900.000	6.29	5657.7	190.0	11120.0
C1	32.850	675.000	56.89	38402.0	-18090.0	94890.0
C2	65.260	600.000	7.98	4790.7	390.0	9180.0
C3	20.590	600.000	.01	4.5	.0	.0
C4	27.290	600.000	2.15	1291.0	-920.0	3510.0
D1	70.010	900.000	45.12	40606.0	380.0	80820.0
D2	52.460	900.000	71.18	64059.0	12560.0	115540.0
D3	50.480	900.000	.18	164.1	30.0	290.0
D4	63.320	900.000	4.32	3884.3	1310.0	6450.0
T.	746.092	11925.000		465371.2	92020.0	838620.0

TABLE 3.2 Biomass by block at Elephant Island during AMLR 1990 Survey 2.

BOX	DIST NM	AREA NM**2	XBAR T/NM**2	B T	RANGE T	
A1	40.290	600.000	8.70	5222.4	-1820.0	12270.0
A2	53.870	600.000	116.35	69811.0	35560.0	104050.0
A3	28.370	600.000	156.75	94048.0	11040.0	177050.0
A4	59.300	675.000	43.16	29130.0	3940.0	54310.0
B1	28.940	675.000	16.21	10943.0	930.0	20950.0
B2	53.970	900.000	148.69	133820.0	-26780.0	294420.0
B3	30.850	900.000	41.40	37264.0	-8070.0	82600.0
B4	26.210	900.000.	.02	18.0	10.0	20.0
C1	32.330	675.000	4.38	2958.4	-350.0	6260.0
C2	108.160	600.000	297.80	178680.0	118370.0	238980.0
C3	56.130	600.000	71.72	43030.0	8400.0	77650.0
C4	30.130	600.000	.85	513.0	40.0	970.0
D1	40.640	600.000	104.52	62714.0	-10020.0	135450.0
D2	46.380	700.000	580.88	406620.0	254840.0	558380.0
D3	29.790	500.000	113.07	56534.0	19630.0	93430.0
D4	45.990	450.000	2.27	1022.1	260.0	1780.0
T.	711.349	10575.000		1132328.0	405980.0	1858570.0

Table 3.3 Biomass by block at Elephant Island during AMLR 1990 Survey 3.

BOX	DIST NM	AREA NM**2	XBAR T/NM**2	B T	RANGE T	
A1	27.700	600.000	.01	7.8	.0	10.0
A2	47.350	600.000	1.88	1129.9	20.0	2230.0
A3	39.800	600.000	71.96	43173.0	4530.0	81810.0
A4	40.340	675.000	2.53	1710.9	-590.0	4010.0
B1	48.600	675.000	.10	66.5	.0	130.0
B2	45.330	900.000	4.83	4347.2	890.0	7790.0
B3	65.050	900.000	4.33	3901.2	1940.0	5850.0
B4	36.000	900.000	10.01	9005.0	-1580.0	19600.0
C1	37.060	675.000	6.12	4133.7	2510.0	5740.0
C2	39.160	600.000	87.18	52308.0	13770.0	90830.0
C3	18.260	600.000	.25	149.2	.0	300.0
C4	39.940	600.000	28.57	17139.0	-2050.0	36320.0
D1	42.120	900.000	231.42	208280.0	-50740.0	467290.0
D2	57.250	900.000	203.22	182900.0	84300.0	281490.0
D3	61.640	900.000	1.67	1501.7	330.0	2670.0
D4	42.830	900.000	64.19	57775.0	8260.0	107280.0
	688.430	11925.000		587528.1	61590.0	1113350.0

Table 3.4 Biomass by block at Elephant Island during AMLR 1990 Survey 4.

BOX	DIST NM	AREA NM**2	XBAR T/NM**2	B T	RANGE T	
A1	39.670	600.000	5.40	3242.8	1440.0	5040.0
A2	48.440	600.000	1.18	710.6	-160.0	1580.0
A3	29.700	600.000	41.01	24607.0	-21720.0	70930.0
A4	55.550	675.000	59.26	40000.0	26780.0	53210.0
B1	52.030	675.000	3.18	2145.0	1140.0	3140.0
B2	39.190	900.000	28.10	25288.0	220.0	50350.0
B3	27.820	900.000	34.86	31377.0	16080.0	46670.0
B4	56.700	900.000	26.78	24098.0	15190.0	33000.0
C1	54.140	675.000	226.52	152900.0	-18210.0	324020.0
C2	42.800	600.000	537.26	322360.0	27890.0	616810.0
C3	48.280	600.000	17.33	10396.0	5120.0	15670.0
C4	52.290	600.000	9.30	5577.3	2160.0	8990.0
D1	15.320	900.000	77.24	69513.0	-810.0	139830.0
D2	49.940	900.000	57.77	51995.0	2490.0	101490.0
D3	45.450	900.000	21.50	19351.0	-4990.0	43690.0
D4	23.350	900.000	18.84	16957.0	2860.0	31050.0
	680.671	11925.000		800517.7	55480.0	1545470.0

4. Phytoplankton/Primary Production Studies, Leg I and Leg II; submitted by Osmund Holm-Hansen, Walter Helbling, and Virginia Villafane.

4.1 Objectives:

Our major research objectives were:

1) Determination of the distribution and concentration of the food reserves available to grazing zooplankton, including krill.

2) Determination of the rate of primary production, which will dictate the time-dependent production of organic food material.

3) To better understand the processes that affect either the distribution of phytoplankton cells or that influence photosynthetic rates.

4) To document floristic composition of the phytoplankton standing stock and to determine if the different water masses are characterized by different key species.

5) To start to develop a model of phytoplankton productivity in Antarctic waters which would permit estimation of rates of integrated primary production based on measurement of chlorophyll distribution, incident solar radiation, light attenuation in the water column, stability of the upper water column, nutrients and temperature.

4.2 Accomplishments:

Four surveys (two in Leg I and two in Leg II) were conducted in the vicinity of Elephant Island. The cruise tracks and locations of the stations are described elsewhere. Leg I included 38 stations and Leg II consisted of 36 stations. Water samples were obtained at all stations at 11 different depths (1, 5, 10, 15, 20, 30, 40, 50, 75, 100m and close to the bottom) by Niskin bottles mounted on a rosette. Chlorophyll-a was measured on all these water samples. At each of the 23 primary stations (12 in Leg I and 11 in Leg II) intensive sampling and studies were completed (e.g., primary production, nutrients, POC, PON, phytoplankton floristics, etc.). Water samples were also obtained at other locations for use in related experiments. Our studies included the following work:

1) Phytoplankton distribution and abundance.

a) Chlorophyll-a (Chl-a), was determined by extraction of photosynthetic pigments into absolute methanol, followed by measurement of chl-a by fluorescence in a Turner Designs Model 10 Fluorometer (Holm-Hansen and Riemann,1978). These measurements were made at 11 depths at all stations in both legs.

b) During Leg I, estimation of total microbial biomass was done by measurement of adenosine triphosphate (ATP). These determinations were completed at only six depths during each of the 12 primary stations. Samples were extracted into boiling TRIS buffer, and the ATP was measured using the firefly reaction method in an ATP-Photometer (Holm-Hansen and Booth, 1966). As the organic carbon/chl-a ratio can vary considerably in Antarctic phytoplankton, data on ATP concentrations are useful in estimating phytoplankton biomass when combined with microscopic examinations.

c) Water samples from all 23 primary stations were preserved in both Lugol's iodine solution and in buffered formalin. Later, inverted microscope techniques will be used to enumerate total number and volume of phytoplankton cells.

d) A transmissometer was mounted on the rosette to give us continuous profiles of beam attenuation in the water column. In the absence of terrigenous material, beam attenuation coefficients permit estimation of total cellular organic carbon. The transmissometer data were acquired during CTD casts by T. Amos and M. Lavender.

2) Distribution and concentration of total particulate organic carbon (POC) and nitrogen (PON).

Samples were taken at the 23 primary stations at 6 depths (1, 5, 15, 30, 50, 75m) and filtered through combusted GF/F filters. The analysis of POC and PON will be done at Scripps Institution of Oceanography (SIO) by combustion of the filtered samples and measurement of carbon and nitrogen by gas chromatographic techniques.

3) Rates of primary production.

Water samples collected from eight depths (1, 5, 10, 15, 20, 30, 40, 50m) during each of the 23 primary stations were incubated with radioactive bicarbonate on deck under simulated light conditions and surface water temperature. The radioactivity of the filtered samples will be measured on a Liquid Scintillation Counter at SIO.

4) Incident solar irradiance.

Incident solar irradiance was monitored continuously during the cruise with a gimble-mounted 2-pi light sensor which records photosynthetically available radiation (PAR) in units of quanta per cm^2. The signal from this light sensor, in addition to signals from two Eppley Pyrheliometers (one total radiation and one for UV radiation), were averaged over one minute and recorded every 10 minutes by Amos' data acquisition system. Continuous profiles of attenuation of solar radiation in the water column were obtained by a cosine PAR light sensor mounted on the rosette.

5) Inorganic nutrients.

Water samples were taken at 10 depths during each of the 23 primary stations for measurement of nitrite, nitrate, silicate, and phosphate. These samples are kept frozen until they are ready for analysis. Ammonia was analyzed on board by the indophenol blue method and the absorbance was read in a Spectronic 2000 spectrophotometer using 5cm cells (Strickland and Parsons,1972).

6) Species composition and cell size of phytoplankton.

The water samples, preserved at the 23 primary stations, will be examined by inverted microscope techniques in order to determine (a) the species composition of the crop, and (b) cell numbers and volumes, from which total cell volume and organic carbon can be estimated. Water samples at selected stations were size-fractionated with a 20um nylon mesh so that phytoplankton biomass can be estimated for the nanoplankton (<20um in effective cell diameter) and the microplankton (>20um in size).

7) Spectral absorption of particulate materials.

Water samples from 6 depths (1, 5, 10, 15, 30, 50m) were taken from the Niskin bottles at the 12 primary stations in Leg I. Due to shortage of water during Leg II (leaking of bottles), samples were taken from 10 stations other than the primary ones. At these stations water was taken from 10 depths. All the samples were filtered through a GF/F filter and were frozen for later analysis at SIO. Absorption spectra will be obtained before and after methanol extraction to determine extinction coefficients and to relate them with the light profile data acquired with the rosette unit.

8) Culture work.

a) During Leg I, water samples were used to initiate phytoplankton cultures which were permitted to grow at controlled light and temperature conditions in a deck incubator for periods of time ranging from days to two weeks. Specific objectives in these experiments involved determination of (a) specific growth rates of phytoplankton, including size-fractionated samples, and (b) whether or not iron is a limiting factor for rates of primary production in Antarctic waters. In order to test the iron hypothesis (Martin and Fitzwater, 1988) it was necessary to use a Zodiak to obtain water samples far from the ship. In these experiments growth was followed daily by measurement of chl-a, but subsamples were taken once or twice during the growth period for determination of ATP, POC, PON, absorption spectra, floristic composition, and inorganic nutrients.

b) During Leg II, phytoplankton cultures were kept under different controlled light conditions in order to answer specific questions related to pigments that absorb in the UV region of the spectrum. Absorption spectra of methanol extracted pigments were analyzed in a Spectronic 2000 spectrophotometer. Samples were also filtered through a GF/F filter to obtain absorbance spectra of the particulate material on the filter (Mitchell and Kiefer,1988). Subsamples were taken at different times during the exponential growth phase for nutrient and floristics analysis.

4.3. Disposition of samples:

Most of the above measurements (e.g., chl-a, ATP, ammonia, light measurements) were completed during the cruise, but samples for the following analyses will be processed at our home laboratories: (a) POC and PON, (b) preserved samples for floristic determination, (c) frozen samples for nitrite, nitrate, phosphate, and silicate concentrations, (d) absorption spectra, and (e) radiocarbon samples for primary production estimates.

4.4. Tentative conclusions:

During both legs, the concentration of phytoplankton in the study area seems to be intermediate between rich coastal areas, such as the Gerlache Strait (Holm-Hansen and Mitchell, 1990), and the low-biomass waters, which are characteristic of the Scotia Sea, Weddell Sea, and Drake Passage (Biggs et al, 1982).

Surface concentration of chl-a was moderate throughout most of the study area (0.2 to 4.0ug/l chl-a in Leg I and 0.3 to 6.3ug/l in Leg II) as shown in Figure 4.1. The integrated phytoplankton biomass (Figure 4.2) is fairly high, 20-300mg Chl-a/m^2, because phytoplankton were generally abundant throughout the upper 50-75m of the water column.

In Leg I chlorophyll maxima appeared between 30 to 50m while in Leg II these maxima, when they occurred, appeared between 40 to 70m. This deepening of the chlorophyll maxima could be related to stronger mixing conditions and a deeper mixed layer during Leg II. Preliminary examination of the physical data seems to support these conclusions.

There was much variability in phytoplankton biomass within the grid surveyed, with the richest areas generally being to the south or east of Elephant Island, and the lowest biomass areas being in the northerly portions of the grid. During Survey 3 of Leg II some higher values of chlorophyll (1.6ug/l) were also seen north of Elephant Island. We do not know if this distribution is related to grazing pressure by krill, but it appears that at least in Leg I the highest krill areas correlated with reduced phytoplankton abundance.

From the information obtained during both legs it seems that higher chlorophyll values are correlated with the Type IV water (eastern Bransfield Strait) determined by T. Amos and M. Lavender during this cruise.

From the size-fractionated samples it seems that in Leg I, nanoplankton account for 50 to 75% of the total crop. In Leg II 60 to 90% of the total crop corresponded to nanoplankton, which may be due to more influence of Bransfield Strait waters in the area of study. This may bear some significance to the apparent decrease in krill abundance in the area of Elephant Island during Leg II, because of the general thought that krill prefer the larger diatoms as compared to the small nanoplankton.

Radiocarbon samples from one station were returned to SIO for preliminary determination of the amount of fixed radioactivity. The results show that the range of light intensities used in our deck incubator were optimal in that they ranged from close to the light compensation point to several points which saturated the photosynthetic rate. The maximal assimilation values appeared to be normal for most Antarctic phytoplankton in that they were slightly more than 1.0.

According to the results of our culture experiments, water within the study area seems to have the nutrient potential for producing phytoplankton crops between 30 to 70ug chl-a/l. We could not find any evidence to support the hypothesis that the low phytoplankton biomass is related to iron limitation. We think it more reasonable and plausible to interpret the moderate phytoplankton standing stocks in relation to physical mixing processes, grazing effects, and settling of cells to deep water.

4.5. Problems, Suggestions and Recommendations:

The major problem which had some impact on the reliability of some of the data we acquired involves the functioning of the rosette unit. There were many problems with Niskin bottles not firing, others leaking so badly that samples could not be obtained, and also occasionally an unknown sequence of firing of the bottles at depth. Another potentially important criticism of our work is that we were doing rate studies with bottles supplied with black (or white) rubber cords. There are many reports in the literature that such rubber cords can be very inhibitory to phytoplankton. On this cruise we tried to minimize this potential problem by withdrawing the water sample as soon as possible once the rosette unit was on the deck. In the future, however, it would be much better if teflon-covered springs could be used in all Niskin bottles, and if the overall functioning of the rosette unit could be improved.

It was anticipated that we would have continuous recording of beam attenuation and ambient light in all profiles done with the CTD unit. Various problems encountered during the cruise resulted in our not getting such data on approximately half of the stations. This should be corrected in future studies. Also, it would be of much interest and use to have a submersible fluorometer connected to the rosette system, so that continuous profiles of chl-a could also be obtained with every CTD cast. We have the fluorometer for this work, and it requires only minor modification to the CTD to integrate this unit with the other units on the rosette.

In future studies it would be of value to have continuous recording of surface chl-a concentrations by measuring *in vivo* fluorescence of chl-a in water from the clean ship intake system. Temperature and salinity would be simultaneously recorded.

4.6. Acknowledgements:

We thank NOAA and the AMLR program for the opportunity to participate in this cruise, which proved to be very productive scientifically and also most enjoyable in regard to all conditions on board ship. We would like to thank all officers and crew of the NOAA Ship *Surveyor* for their enthusiastic support and help, which was always cheerfully given us. We also thank M. Lavender and S. Rosales for all their help during both legs.

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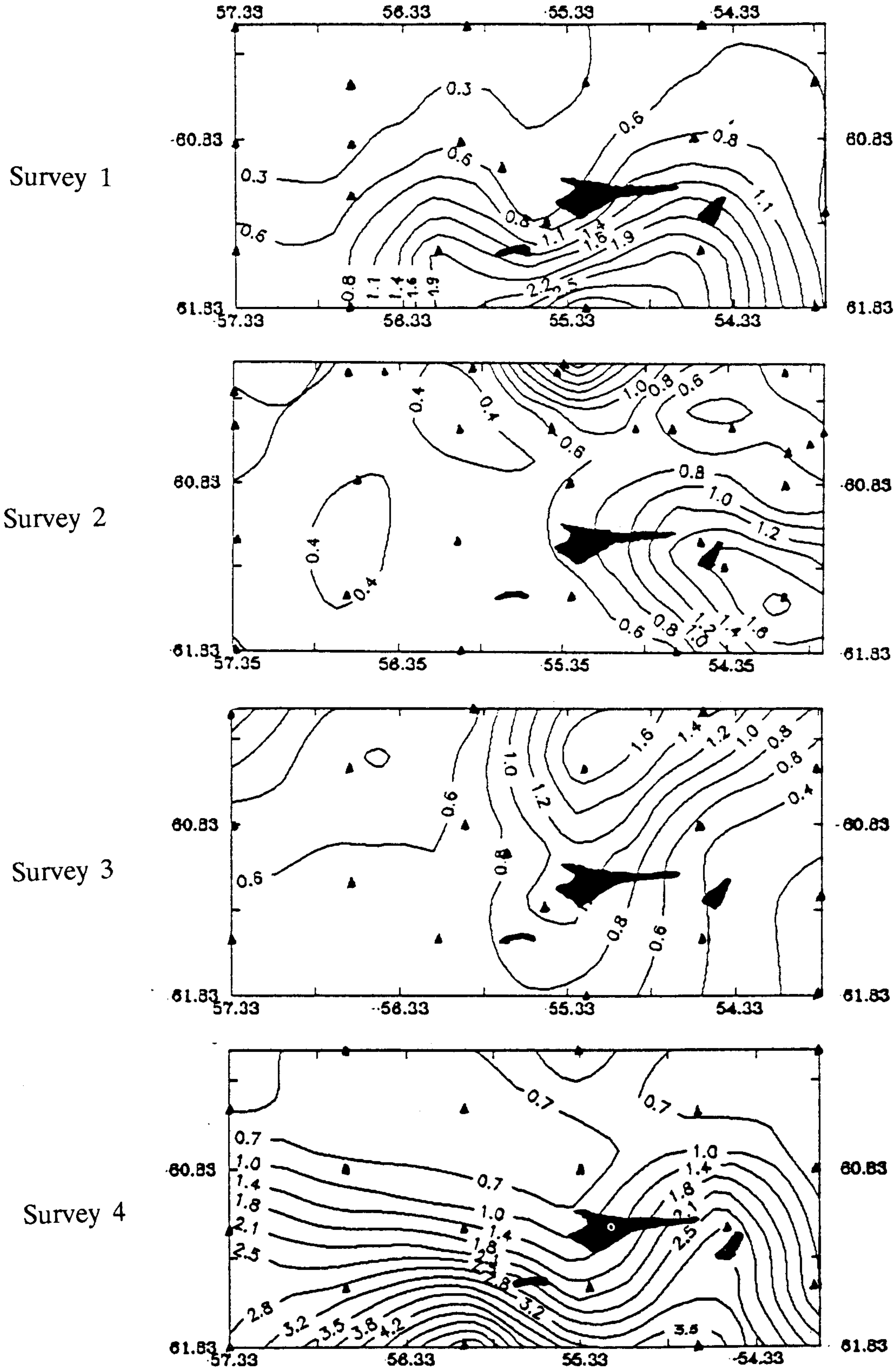

Figure 4.1 Concentration of chlorophyll-a (mg/m^3) in surface water of the AMLR study grid during 1990. Survey 1, Jan. 6-11; Survey 2, Jan. 17-22; Survey 3, Feb. 7-12; Survey 4, Feb. 19-26.

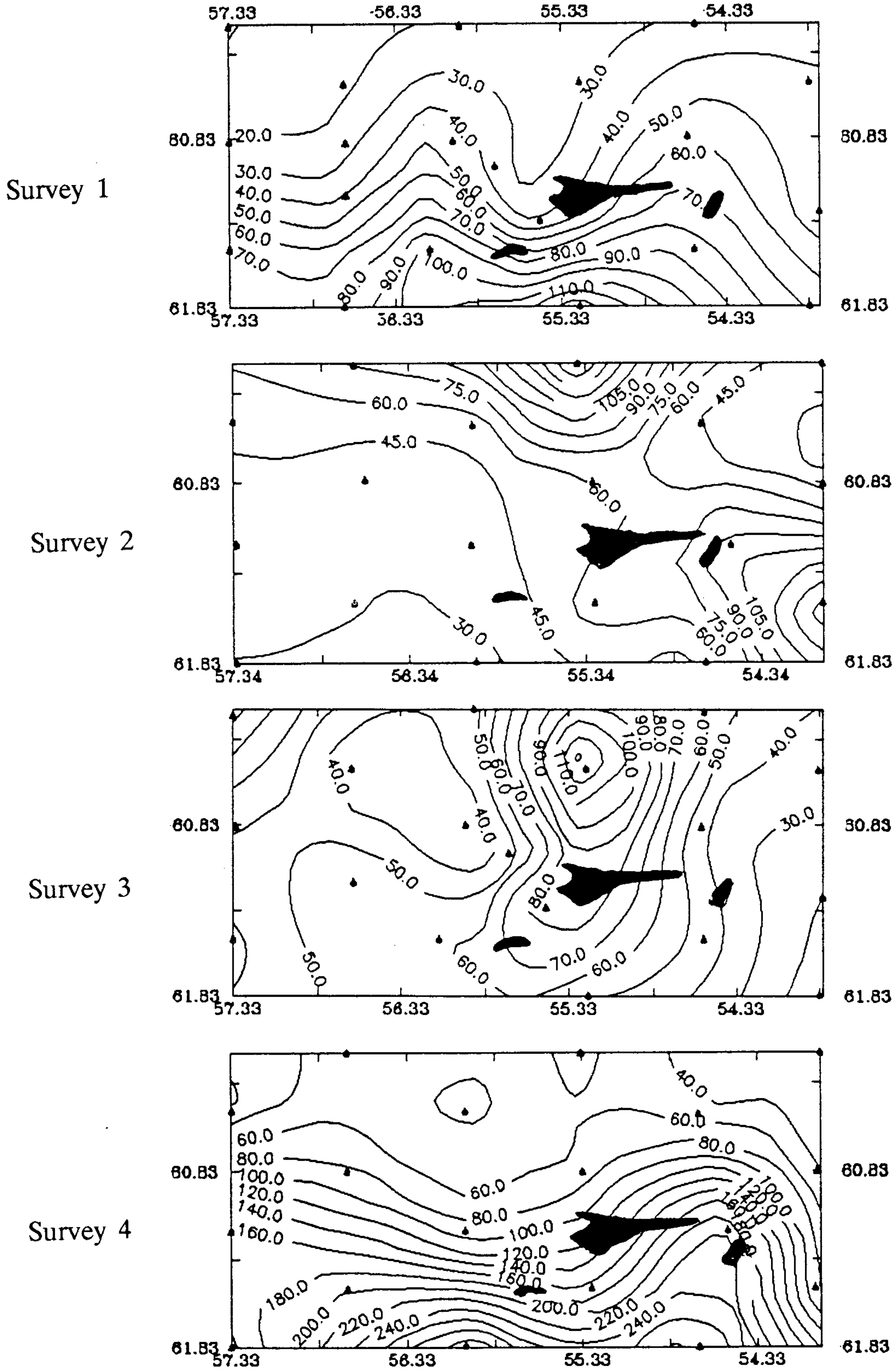

Figure 4.2 Concentration of integrated chlorophyll-a (mg/m^2) in the upper water column (0 to 100m) of the AMLR study grid during 1990. Survey 1, Jan. 6-11; Survey 2, Jan. 17-22; Survey 3, Feb. 7-12; Survey 4, Feb. 19-26.

5. Seal Island logistics and operations during 1989/90; submitted by J.L. Bengtson.

5.1 Objectives:

The AMLR Program maintains a field camp at Seal Island, South Shetland Islands, Antarctica (60°59.5'S, 55°24.5'W), in support of land-based research on marine mammals and birds. The camp is occupied during the austral summer field season, which normally runs from December through February. The main logistics objectives of the 1989/90 season were:

1)To deploy the field team early in December aboard the M/V *Society Explorer* in order to arrive at Seal Island in time to monitor fur seal pupping and penguin chick hatching,

2)To resupply the field camp with its season's provisions, which were transported from the United States aboard the NOAA Ship *Surveyor*,

3)To perform a health and safety inspection of Seal Island operations,

4)To install enhanced radio communications systems on the island and to maintain daily radio contact with either Palmer Station or the NOAA Ship *Surveyor*,

5)To repair, maintain, and improve camp facilities at the Seal Island field camp,

6)To repair and maintain the National Weather Service automatic weather station, and

7)To retrograde trash and other cargo from the island and to transport the field team to Chile at the end of the season aboard the NOAA Ship *Surveyor*.

5.2 Accomplishments:

The five person field team flew by chartered aircraft from Punta Arenas to Puerto Williams, Chile, to embark the tour ship M/V *Society Explorer* on 7 December. The ship arrived at Seal Island on 14 December and the field team disembarked at 2300. Good weather resulted in an efficient landing at the camp beach with 2 Zodiac loads of cargo. Dry conditions and no snow on the ground facilitated setting camp up on 15 December. There was no overwinter damage to any structures or supplies at camp. Although the research team arrived in time to observe penguin hatching, it was about 2 weeks late for the peak of fur seal pupping.

The NOAA Ship *Surveyor* arrived at Seal Island on 4 January, and offloaded cargo on 5 January. Cargo operations began at 0800 and finished at 1700. Two Mark V Zodiacs were used to transport supplies ashore. Landing conditions were good at the sand beach near camp, and a total of 20 Zodiac loads was brought ashore without difficulty. The assistance of ship's personnel and members of the scientific party expedited cargo operations. In addition to the persons who came ashore to help unload and carry cargo up to camp, four divers in dry suits were stationed to steady the Zodiacs during unloading.

Lt. A.M. Smith, USPHS, the *Surveyor's* medical officer, and LCDR C.P. Berg, the ship's Field Operations Officer, came ashore on 12 January for a health and safety inspection of the island's facilities. In addition to inspecting the main camp area, a visit was made to North Cove, where an observation blind is maintained as an emergency shelter.

Two new radio systems were installed at Seal Island during the 1989/90 season. A 40 Watt VHF radio transmitter was set up on the top of the island (135m elevation) in early January. The transmitter is remotely-controlled from the main camp. This VHF radio has a radio range of up to 125km, and was used as the principal method of communicating with the NOAA Ship *Surveyor* when it was operating in the Elephant Island survey area. The second radio installed this season was an ATS-3 satellite communications system. The voice portion of this system was operational by 24 January, allowing Seal Island personnel to patch into U.S. commercial telephone lines. INMARSAT telephone call to the *Surveyor* could also be made during scheduled ATS-3 times. The data transmit/receive portion of the system provided the capability of sending and receiving electronic mail via the OMNET system. The ATS-3 system was very useful, and proved to be a valuable addition to Seal Island communications.

Daily radio communications were maintained with Palmer Station from 14 December to 3 January and from 27 January to 8 February when the *Surveyor* was not within radio range. In addition to these regular schedules, radio contacts were made with biologists and other personnel at Palmer station (U.S.); Commandante Ferraz Station (Brazil); Admiralty Bay camp, King George Island (U.S.); Stinker Point camp, Elephant Island (Brazil); M/V *Society Explorer* (U.S.); R/V *Alcazar* (Chile); and R/V *Barao De Teffe* (Brazil).

Routine maintenance of camp facilities was undertaken as necessary. Obsolete and unneeded equipment was identified and removed from the island for shipment to the U. S. Wooden structures were painted and weatherproofed. Two new structures were added this season: an observation blind and a supplies storeroom. To facilitate behavioral and nesting observations at one of the principal penguin study areas, an observation blind was assembled and put in place. This blind will allow researchers next season to obtain data on penguin breeding success according to CCAMLR protocols with a minimum of disturbance to the colony. To protect overwintering cargo better (in previous years we have kept boxes tarped outside) a small storeroom was added to the equipment shed.

The NWS remote weather station at Seal Island was blown down and damaged during the 1989 winter. During the 1989/90 summer season, the antenna tower, GOES satellite antenna, one solar panel, temperature/humidity sensor, and power supply were repaired. A new barometric was also installed. Although the repaired unit appeared to be collecting data and transmitting to the GOES satellite on schedule, consultations with NWS personnel indicated that transmissions from the Seal Island station were not being received correctly in the U.S. Therefore, all sensors and the transmitter were disassembled and shipped to the U.S. for repairs.

During the initial resupply of Seal Island on 5 January, the trash from the 1988/89 season was transported to the NOAA Ship *Surveyor* for proper disposal. This trash had been stored at Seal Island during the winter because rough seas at the conclusion of the 1988/89 season had precluded offloading when the field team was picked up. Additional trash and retrograde cargo was transported to the *Surveyor* each time that the ship called at Seal Island throughout the season to minimize the amount of cargo necessary to offload at the end of the season. All remaining trash and cargo was loaded onto the ship on 27 February, when the camp was closed and the field team embarked the ship for transport to Chile.

5.3 Problems, Suggestions and Recommendations:

An arrival date of 1 December would be preferable to a mid-December arrival because fur seal studies could be initiated during the period of peak fur seal pupping. Such a starting date would provide a better sample of perinatal female fur seals as well as an opportunity to obtain data on fur seal females' early feeding trips before their pups fall prey to leopard seals.

Although daily radio communications with Palmer Station and the *Surveyor* were successful for the most part, repeated difficulty in contacting the *Surveyor* was encountered during Leg II. Even during times when the ship was out of VHF range, it should have been possible to contact the ship on the single side band (HF) radio at most times. On several occasions Seal Island personnel called the ship for extended periods following the scheduled contact time before the ship answered. In some of these instances, when the ship did answer, the radio signal was loud and clear, suggesting that the HF radio was not previously being monitored or working correctly. Although the HF radio on the bridge was usually set on the assigned monitoring frequency of 4125 MHz, the volume may sometimes have been turned down so that static or other traffic would not disturb personnel on the bridge. In future seasons, steps should be taken to ensure that 4125 MHz is monitored in such a way that calls to the ship will be heard during the scheduled contact time as well as any time that Seal Island personnel may need to call the ship for assistance.

Boating operations at Seal Island went relatively smoothly during cargo operations; however, there are a number of procedures that should be clarified and followed in the future. Zodiac drivers should be advised to follow the instructions of personnel ashore in choosing a landing spot, which will help drivers inexperienced with the Seal Island landing spots to avoid potential problems. In general, when landing at the sand beach near camp (Beaker Bay Beach), the optimal landing spot is in the protected area at the south part of the beach where the bottom slope is steeper. The surf is often higher in the central portion of the beach due to the long, gentle slope of the bottom in that area. When Zodiacs are launched from Beaker Bay Beach, they must be turned so that they are launched bow first into the surf. Launching a Zodiac stern first into the surf increases the chances of being swamped, turned sideways, or rolled by the waves.

6. Pinniped research at Seal Island; submitted by Peter Boveng, Michael E. Goebel, and J.L. Bengtson.

6.1 Objectives:

During the 1989/90 field season, the objectives of the pinniped research at Seal Island were:

1)To monitor pup growth and condition and adult female foraging trips of Antarctic fur seals according to CCAMLR Ecosystem Monitoring Program protocols,

2)To conduct directed research on reproductive success, female foraging behavior, diet, and abundance, survival and recruitment of fur seals, and

3)To monitor the abundance of all other pinniped species ashore.

6.2 Accomplishments:

REPRODUCTIVE SUCCESS

Daily counts were made of fur seal pups at the North Cove and North Annex study sites. The maximum number of live pups observed at North Cove was 249 on 27 December. The maximum count at North Annex was 41 on 7 January. Prior to those dates, 2 dead pups were observed, suggesting that a minimum of 292 pups were born this season at the two sites. The total number of pups at the two sites declined to about 94 by 4 February 1990 and remained relatively constant thereafter. A major source of pup mortality was predation by leopard seals.

A census on 12 January of the fur seal rookery on a nearby island (Large Leap Island) revealed at least 260 pups were born there this year. A total of 130 pups was seen during a second count of that rookery on 27 February. The magnitude of this decrease suggests that leopard seal predation may not be as common at this rookery as it is at North Cove.

FORAGING BEHAVIOR

Time-depth recorders (TDRs) were attached to 14 female fur seals between 18 and 20 December 1989. All 14 females were perinatal (ashore with a newborn pup, before the first feeding trip) at the time of instrument attachment. A second sample of 8 female fur seals with pups was instrumented with TDRs and head-mounted radio transmitters on 9 and 10 January 1990, as part of the study of at-sea tracking to foraging areas conducted from the NOAA Ship *Surveyor*. All TDRs were recovered between 12 January and 15 February 1990. At least 19 of the 22 instruments appear to have functioned properly. The dive records will be analyzed at the National Marine Mammal Laboratory (NMML) to provide estimates of the foraging effort required by females raising pups.

The 22 female fur seals with TDRs, as well as an additional 27 females with pups, were instrumented with radio-transmitters, allowing continuous monitoring of presence and absence at the rookery. Of the 39 radio-transmittered females with pups, 24 were perinatal.

The CCAMLR Ecosystem Monitoring Program (CEMP) Standard Method for estimating foraging trip duration (C.2.) specifies that the first six feeding trips made by each female be used for estimation of the parameter. Therefore, only females instrumented during their perinatal periods can be included in the sample. The sample size is limited further because some females do not complete six feeding trips before losing their pups. Estimation of mean foraging trip duration will be completed at NMML.

DIET

Fur seal feces were collected at bi-weekly intervals. Each sample consisted of 10 scats from each sex. The scats were put in frozen storage aboard *Surveyor* for analysis of prey remains at NMML.

ABUNDANCE, SURVIVAL, AND RECRUITMENT

Pup counts form the best index of abundance for fur seals because the pup cohort is the only age class found ashore in its entirety during a particular census. The maximum number of pups counted at North Cove, 249, was approximately the same as last year. The North Annex colony increased from about 23 pups last year to 41 this year.

Daily observations were made of fur seals tagged in this and previous years to assess survival and recruitment to the breeding population. Of 37 adult female fur seals that had pups and were tagged last year, 30 were observed at least once this year (27 observed with pups this year). Ten fur seals tagged as pups in previous years were observed this year. As yet, no fur seals tagged as pups at Seal Island have been observed breeding.

Between 29 January and 25 February, 114 pups were tagged with metal flipper tags. The members of this and previously tagged cohorts that survive to breeding age will allow future estimation of parameters such as age at first reproduction and recruitment rates.

GROWTH AND CONDITION

Fur seal pups were weighed at approximately 14-day intervals between 1 January and 25 February 1990 (Table 6.1). Male pups grew at a mean rate of about 112 grams per day (s.e.=7.4). Females grew at a rate of about 94 grams per day (s.e.=5.1).

Table 6.1 Mean weights, standard deviations, and sample sizes of male and female fur seal pups weighed during 5 sampling intervals in 1990.

	Sampling Dates				
	1-3 Jan	14-15 Jan	29-31 Jan	12-13 Feb	25 Feb
MALES:					
mean wt. (kg)	9.00	11.01	13.11	13.84	14.89
st. dev.	1.42	1.69	2.01	2.13	1.93
n	54	55	32	32	17
FEMALES:					
mean wt. (kg)	7.23	9.17	10.66	11.54	12.31
st. dev.	1.02	1.22	1.31	1.63	1.60
n	48	45	50	42	34

The CEMP Standard Method for monitoring pup growth rates (C.1.) is designed to give 90 percent confidence that a change (between or among years) in the growth rate of about 10 percent would be detected using $\alpha = 0.10$. Because the confidence to detect such a change is dependent on the length of the monitoring period and because the monitoring period is limited by the date on which *Surveyor* must leave the study area, it is extremely important to obtain a sufficient sample size during the last weighing of the season. This year we were limited to one day of sampling for the last weighing, which may compromise the ability to detect future changes in pup growth rates.

ABUNDANCE OF OTHER PINNIPEDS

Abundance of all pinniped species ashore on Seal Island[1] was monitored by conducting weekly censuses. During these weekly censuses fur seals were tallied by sex and reproductive status (Table 6.2) and other species were recorded as total number present (Table 6.3).

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[1]A small fur seal rookery on the northeast side of the island was not censused regularly. Opportunistic counts of that rookery suggested that 7 pups were born there. Occasionally, solitary leopard seals were also sighted ashore there.

Table 6.2 Weekly counts of Antarctic fur seals, by sex and reproductive status, at Seal Island, Antarctica, 1989/1990.

Date	Pups	Adult Females	Adult Males With Females	Adult Males Without Females	Subadult Males
19 Dec	251	137	35	33	7
26 Dec	262	92	26	32	6
02 Jan	252	95	26	18	4
09 Jan	256	124	26	18	20
17 Jan	192	143	11	26	92
23 Jan	119	162	13	15	47
31 Jan	101	157	16	51	106
06 Feb	89	144	15	38	168
13 Feb	84	115	14	36	174
20 Feb	89	83	8	25	107

Table 6.3 Weekly counts of pinnipeds other than Antarctic fur seals at Seal Island, Antarctica, 1989/1990.

Date	Leopard Seals	Weddell Seals	Elephant Seals
19 Dec	0	2	42
26 Dec	1	1	29
02 Jan	0	2	10
09 Jan	0	1	5
17 Jan	0	3	16
23 Jan	0	2	17
31 Jan	0	2	20
06 Feb	0	1	6
13 Feb	0	5	11
20 Feb	0	4	2

6.3 Tentative Conclusions:

Nearly all the objectives for pinniped research at Seal Island this season were met. Though most of the study parameters will require analysis at NMML, first impressions suggest that reproduction, foraging effort and diet were similar to those in previous years. Pup growth rates appear slightly lower than in the previous two years, though further analysis will be required to determine whether the difference is significant.

The role of leopard seals in regulating local fur seal populations (as well as populations of other krill predators) may warrant directed studies in the future.

6.4 Problems, Suggestions and Recommendations:

Support by *Surveyor* of the pinniped research at Seal Island was very good, and contributed substantially to a successful season of research. This season the Seal Island field team was put ashore at the study site by the M/V *Society Explorer* on 14 December 1989. By that date, most fur seal births had already occurred and, as discussed in the section on Foraging Behavior, obtaining a sufficient sample of perinatal females was difficult. Also, it was not possible to estimate the date of peak births, which is important for timing of the CEMP Standard Methods. It is therefore recommended that the AMLR Program use whatever means are available to facilitate earlier arrival (approximately 1 December) of the Seal Island field team in future seasons.

7. Seabird research at Seal Island, Antarctica; submitted by Donald A. Croll, Steven D. Osmek, and J.L. Bengtson.

7.1 Objectives:

Five species of seabird breed on Seal Island: chinstrap penguins (*Pygocelis antarctica*), macaroni penguins (*Eudyptes chrysolophus*), cape pigeons (*Daption capensis*), Wilson's storm petrels (*Oceanites oceanicus*), and kelp gulls (*Larus dominicanus*). Southern giant petrels (*Macronectes giganteus*) breed on adjacent islands. Penguins forage over large areas of the continental shelf searching for food, acting as samplers of the marine environment. During the breeding season they are tied to one location ashore where they return repeatedly throughout a 4 to 5 month period. Being flightless seabirds, they are limited in the distance they are able to forage from the breeding site. Therefore, aspects of their behavior and ecology reflect biotic and abiotic conditions adjacent to their land-based breeding areas. The principal research objectives for the 1989/90 field season were:

1)To monitor the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap and macaroni penguins according to CCAMLR Ecosystem Monitoring Program protocols (CEMP),

2)To conduct directed research on chick growth and condition, and diving behavior of chinstrap and macaroni penguins,

3)To assess the reproductive success, survival, and recruitment of cape petrels, and

4)To evaluate the potential effects of electronic instruments on the behavior of penguins.

7.2 Accomplishments:

REPRODUCTIVE SUCCESS AND CHRONOLOGY

Breeding success was estimated according to CEMP Standard Methods A.6.B. (observations of 100 nest plots) and A.6.C. (discrete counts of colonies). Method A.6.B. is designed to determine the number of chicks raised to the creche stage for a set of individual nests. Rectangular plots of 100 individually-marked chinstrap nests each were marked by stakes in 2 colonies. A sample of 40 macaroni penguin nests at Mac Top were also identified and monitored. Each nest in the plot was examined initially by gently lifting the adult and looking underneath, or, if possible, by observation with binoculars. Every other day thereafter each nest was observed from the blind with a spotting scope (without entering the colony) and the number of incubated eggs or brooded chicks was recorded. Overall, for the chinstraps, a total of 1.1 chicks/active nest were raised to creching at the Parking Lot plot, while 0.8 chicks/active nest reached the creche stage at North Cove (Figures 7.1 and 7.2).

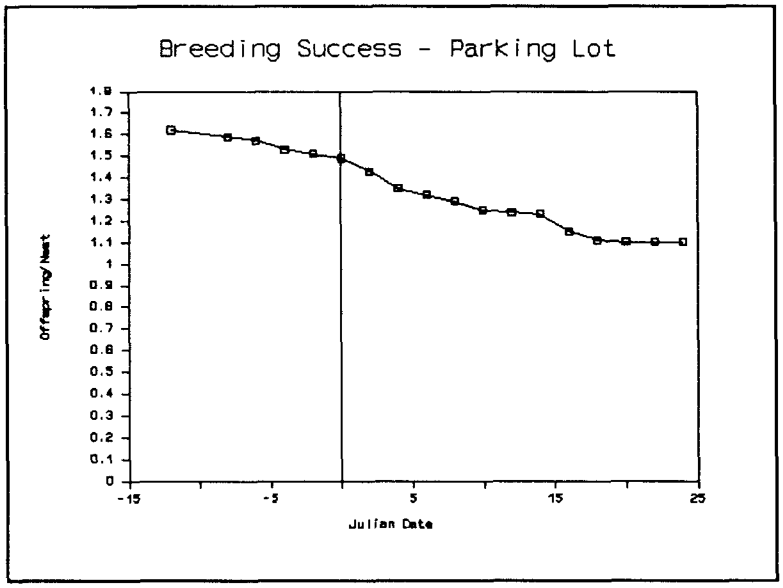


Figure 7.1 Chinstrap penguin breeding success at Parking Lot study plot, Seal Island 1989/90.

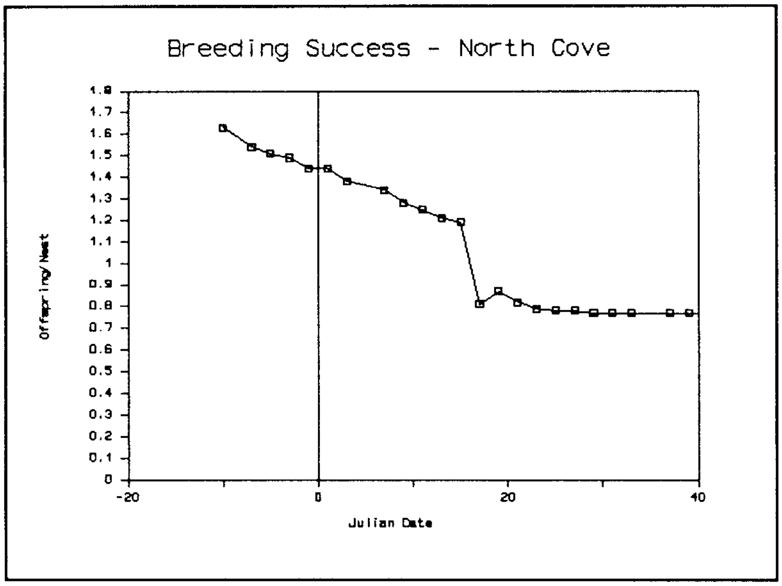


Figure 7.2 Chinstrap penguin breeding success at North Cove study plot, Seal Island, 1989/90.

The number at North Cove was considerably lower due to a strong storm that swept waves through the lower half of this colony on 16 January, causing the loss of 27% of the chicks in the study plot.

These plots were also used to determine the chronology of penguin reproductive events at Seal Island through creching. The rate of chinstrap penguin hatching peaked on 23 December at the Parking Lot plot and 26 December at North Cove. Creching began on 20 January and 21 January and was completed by 24 January and 10 February in the Parking Lot and North Cove plots respectively. Macaroni hatching began on 19 December and peaked on December 25. All chicks had hatched by 16 January. Macaroni creching began on 12 January and was completed by 28 January. Fledging began on 3 February and was completed on 27 February. The number of macaroni chicks/active nest raised to creching at Mac Top was 0.8, while 97% of these chicks survived to fledging, giving a fledging success rate of .78 fledglings/active nest. Upon completion of creching, the number of creched chicks were counted every other day in colony 66 (a colony of about 300 nests) to provide an estimate of mean date of fledging. Fledging began in on 5 February, while the fledging rate peaked around 14 February.

According to CEMP Standard Method A.6.C., two censuses were made of 10 geographically discrete chinstrap colonies undisturbed by other activities. Each of the four macaroni penguin colonies was also censused. When hatching was complete, the number of nests with chicks and the number of chicks in each nest was counted. When creching was complete, the total number of chicks in each colony was counted (Tables 7.1 and 7.2).

Table 7.1 Census results for macaroni penguins at the conclusion of egg laying, completion of hatching, and completion of creching at Seal Island, 1989/90.

Date	Colony	Area Name	1 Egg	1 Chick	Empty Nests
Completion of egg laying					
20 Dec	4	Mac Top	37	0	3
18 Dec	31	Mac Peak	67	0	6
20 Dec	71	Macaroon	76	0	23
26 Dec	74	Macadamia	116	0	16
26 Dec	61	Big Boote	6	0	0
		Totals	302	0	48
Completion of hatching					
8 Jan	4	Mac Top	4	32	4
8 Jan	31	Mac Peak	8	47	16
9 Jan	71	Macaroon	7	47	22
9 Jan	74	Macadamia	14	79	36
9 Jan	61	Big Bootie	1	4	0
		Totals	34	209	78
Completion of creching					
3 Feb	4	Mac Top	0	32	-
2 Feb	31	Mac Peak	0	46	-
5 Feb	71	Macaroon	0	59	-
5 Feb	74	Macadamia	0	87	-
5 Feb	61	Big Boote	0	3	-
		Totals	0	227	-

Table 7.2 Summary of breeding success censuses of chinstrap penguins, Seal Island, 1989/90.

Date	Colony	Mean	SD
Nests with eggs at arrival on Seal Island			
21 Dec	9	360.0	8.3
22 Dec	21	75.7	2.9
20 Dec	24	19.3	0.5
22 Dec	31	346.3	9.8
21 Dec	32	97.0	0.8
22 Dec	33	139.0	5.4
22 Dec	42	198.0	5.7
22 Dec	51	44.0	2.4
22 Dec	54	259.3	9.0
22 Dec	66	274.0	9.0
Chicks post hatching			
6 Jan	9	383.0	8.8
7 Jan	21	93.0	2.9
8 Jan	24	20.7	0.5
8 Jan	31	363.0	9.0
6 Jan	32	126.0	5.7
7 Jan	33	202.0	6.4
8 Jan	42	281.7	7.6
8 Jan	51	60.3	1.2
7 Jan	54	343.0	10.0
6 Jan	66	285.7	23.8
Creched chicks			
2 Feb	9	351.3	11.9
2 Feb	21	86.7	0.5
2 Feb	24	1.0	0.0
2 Feb	31	354.0	2.4
2 Feb	32	108.7	1.9
2 Feb	33	181.7	2.4
2 Feb	42	241.0	2.9
2 Feb	51	7.0	0.0
2 Feb	54	147.3	2.5
2 Feb	66	312.7	5.2

Table 7.3 Census of chinstrap and macaroni penguin nests incubating eggs upon arrival of field party at Seal Island, 1989/90.

Date	Area	Mean	Std	Var	N
Chinstrap Colonies					
12/21	9	360.0	8.3	68.7	3.0
12/22	21	75.7	2.9	8.2	3.0
12/20	24	19.3	0.5	0.2	3.0
12/22	31	346.3	9.8	96.9	3.0
12/21	32	97.0	0.8	0.7	3.0
12/22	33	139.0	5.4	28.7	3.0
12/22	42	198.0	5.7	32.7	3.0
12/22	51	44.0	2.4	6.0	4.0
12/22	54	259.3	9.0	80.9	3.0
12/22	66	274.0	9.0	80.7	3.0
Macaroni Colonies					
12/20	4	37			
12/18	31	67			
12/20	71	76			
12/26	74	116			
12/26	61	6			

Three replicate counts were made of each colony on the same day. If one of the three counts differed by more than 10% of any other count, a fourth count was made. The mean and standard deviation of the three (or four) counts was computed as an estimate of the parameter (Table 7.2).

FORAGING BEHAVIOR

The duration of foraging trips was monitored to determine the amount of time at sea required by breeding adults to meet their own energetic needs and procure food for chicks, serving as an indicator of foraging effort and prey availability (CEMP Standard Method A.5.). Forty adult chinstrap penguins (20 nests) and 10 macaroni penguins (5 nests) were equipped with radio transmitters to monitor their presence ashore. An automatic scanning radio receiver and data logger recorded the attendance of radio-tagged birds within 15 minutes of arrival or departure. These nests were checked daily for survival of chicks, and the adult in attendance was recorded as a visual cross check of the automated recorder data.

To provide detailed information on penguins' diving behavior at sea, 12 chinstrap and 6 macaroni penguins were equipped with time-depth recorders (TDRs) which recorded dive profiles and time ashore. Eleven chinstrap and 5 macaroni records were obtained.

DIET

Between 13 January and 17 February 1990, a total of 40 stomach content samples was collected from breeding chinstrap penguins (CEMP Standard Method A.8.). The sampling schedule was divided into 8 5-day collection periods. Adult birds were captured immediately upon returning to the colony after feeding trips to sea and weighed prior to sampling. Stomach samples were obtained by lavaging with warm water. Prior to being released after lavaging, birds were reweighed, measured, and dyed (to ensure that the bird was not handled again during the season).

Samples were sorted into four major prey categories: cephalopods, fish, crustaceans, and unidentifiable. Although further detailed analysis needs to be conducted to determine size, sexual stages and species of prey items, preliminary analyses suggest that krill in this year's samples were larger and more often mature than samples obtained during the 1988/89 season.

ABUNDANCE, SURVIVAL, AND RECRUITMENT

The number of breeding pairs of all penguin colonies on the island was censused. The census was made after the completion of egg laying. All birds lying down were assumed to be occupying a nest site, and were thus considered breeding. Large colonies (4, 14, 25, and 26) were counted from photographs. During the 1989/90 season, there were approximately 19,000 chinstrap penguin nests and 350 macaroni penguin nests active on Seal Island.

To compare the number of birds attempting to breed in specific colonies from year to year, adult penguins were censused at 10 selected chinstrap colonies and at each of the 5 macaroni penguin colonies (Table 7.3). Ideally, the counts should be made at the completion of egg laying. However, due to this year's mid-December arrival date, this count was made prior to hatching. The number of occupied nests was counted in selected colonies upon arrival of the field team.

To estimate annual survivorship and recruitment into the breeding population, 2,000 chinstrap and 83 macaroni penguin chicks were banded. By resighting banded birds in subsequent years, an estimate of age specific annual survival and recruitment can be calculated. Both systematic and opportunistic surveys to resight banded birds were conducted throughout the season.

GROWTH AND CONDITION

The growth rates of chinstrap penguin chicks were monitored by measuring the weight, culmen length, culmen depth, wing length, and noting the status of juvenile plumage molt every 5 days between 6 January and 16 February at colony 4. Prior to creching, the chicks contained in 30 nests were measured. After creching, a total of 75 chicks was measured. After handling, chicks were dyed to avoid sampling them more than once during the season. Mean chinstrap chick weight peaked at 3.4kg on 6 February (Figure 7.3).

Following the initiation of chinstrap penguin fledging on 5 February, daily samples of fledglings present on Beaker Bay were weighed (CEMP Standard Method A.7.A.) until researchers' departure on 27 February; 154 fledglings were weighed.

Macaroni chick weight, culmen length, culmen depth, and wing length were measured and the status of juvenile plumage molt was noted when banding chicks just prior to fledging. Mean (± sd) weights at this time were 2.9kg (±0.5), culmen length and depth were 43.84mm (±3.97) and 16.87mm (±1.40) respectively, while mean wing length was 110cm (±5).

EFFECTS OF INSTRUMENTS

In order to assess the possible effects of electronic instruments on the behavior of chinstrap penguins, the attendance patterns of nesting birds with and without instruments was compared. Thirty birds equipped with radio transmitters and 8 birds equipped with dive recorders were compared with a control group of 60 birds without instruments but marked with dye. The attendance of each of these birds at their nests in North Cove was monitored by continuously observing their nests for 48 hours.

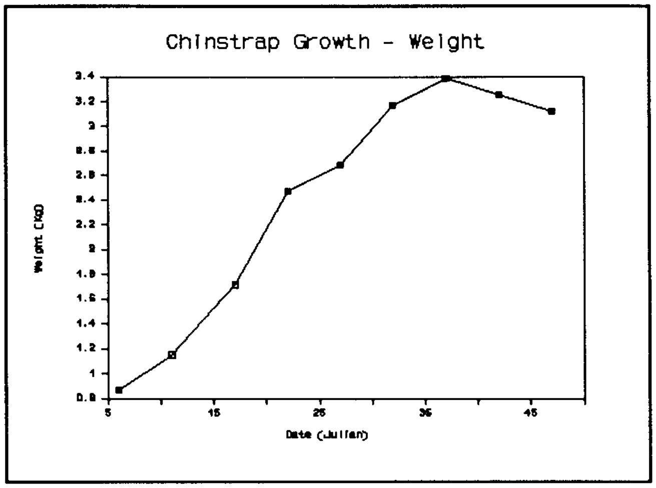
CAPE PETRELS

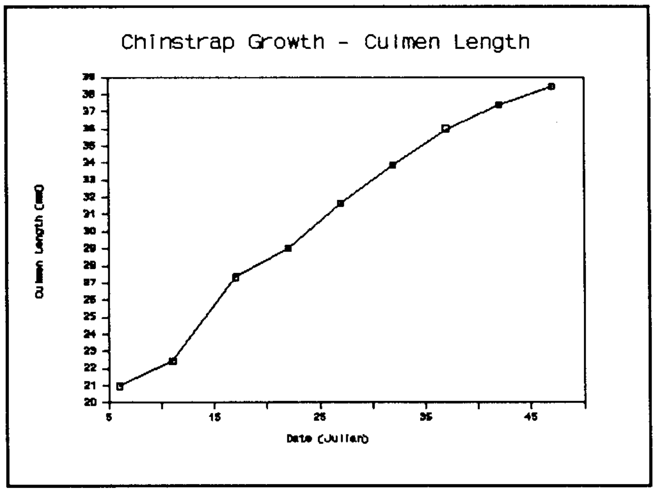
The breeding success of 59 accessible Cape Petrel nests was estimated by surveying nests 4 times during the season. The status of nests was recorded (occupied but empty, unoccupied and empty, incubated egg, attended chick, or unattended chick). Nesting success was estimated at .53 chicks/active nest on 17 February when chicks were banded, weighed, and measured. Material regurgitated by chicks during banding indicated that most chicks were being fed krill. A chick that had been found dead on 24 January weighed 134 grams. Upon dissection, a single squid beak was found in the stomach and sent to Seattle for identification.

7.3 Tentative Conclusions:

Overall, reproductive success at Seal Island during the 1989/90 season was, in almost all respects, the highest observed in the past 3 years for both penguin species. More nests were attempted, more eggs were laid, and more chicks hatched in 1989/90 than in 1987/88 or 1988/89. Both hatching success and creching success were the highest yet recorded. Interestingly, peak chick weight and mean fledgling weights in chinstraps were lower in 1988/89 than those observed previously. This may indicate that in better years, more chinstrap penguins may be able to raise a two egg clutch to fledging. However, this may come at a cost of overall lower chick weights.

As observed in previous years, krill dominated the diet of chinstrap penguins. Preliminary data indicate, however, that chinstraps sampled early in the day may have a higher percentage of fish (mostly myctophids), perhaps suggesting that the birds are taking advantage of this prey resource as it rises closer to the surface during the night. A macaroni penguin found dead on the beach from a probable fall was found to have a high percentage of myctophids in its stomach as well. A more detailed analysis of dive records and a comparison of the records of chinstrap and macaroni penguins should shed some light on this question.





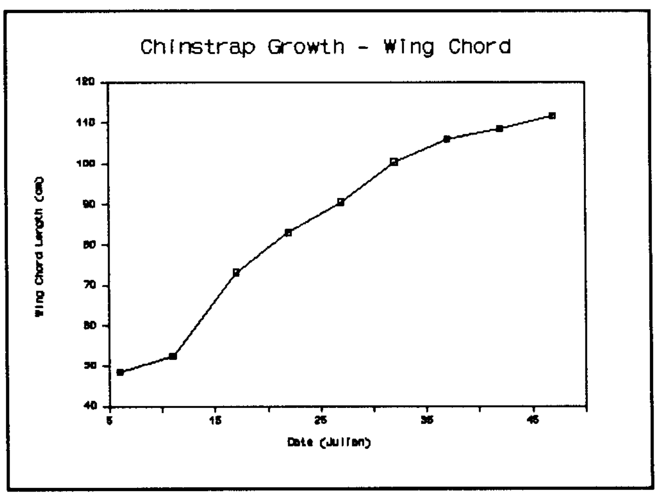


Figure 7.3 Chinstrap penguin chick growth, Seal Island 1989/90.

7.4. Problems, Suggestions and Recommendations:

Study plots have been marked with stakes at both 100-nest study plots. It is recommended that these plots be monitored in subsequent years to provide an interannual comparison of nesting success. Because of the presence of observation blinds at both of these sites, the plots may be monitored without interference by the investigator. It is also recommended that the timing of counts and other activities such as banding be based on benchmark dates (i.e. completion of hatching, completion of creching, etc.) determined by the chronology studies at these study plots, rather than predetermined dates.

8. Seabird research undertaken as part of the NMFS/AMLR ecosystem monitoring program at Palmer Station, 1989-1990; submitted by William R. Fraser and David G. Ainley.

8.1 Objectives:

Palmer Station is one of two active sites on the Antarctic Peninsula where long term monitoring of seabird populations is being undertaken in support of U.S. participation in the Commission and Scientific Committee of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). Research at Palmer Station focuses on aspects of the ecology of Adelie penguins that are complementary to the scope of research outlined by CCAMLR, and as such follows CCAMLR recommended field protocols designed to insure that data collection is comparable year to year both between and within research sites. Our objectives during 1989-1990, the third season of field work at Palmer Station, therefore, were to: 1) establish indices of Adelie breeding success, 2) gather information on Adelie diet composition and meal size, 3) determine Adelie chick weights at fledging, 4) determine the amount of time breeding adult Adelie penguins need to procure food for their chicks, 5) band a representative sample (1000 chicks) of the Adelie chick population, and 6) map the Adelie colonies being used for AMLR related research.

8.2 Accomplishments and tentative results:

AMLR related field work at Palmer Station was initiated on 5 January and terminated on 13 March 1990. Field work schedules and activities related to the above cited objectives were as follows:

1. Adelie breeding success.

As in past years, two indices of breeding success were established. On 5 January, the proportion of 1 and 2 chick broods was determined at 33 colonies in 5 different rookeries; on 20 January, 39 colonies within these same rookeries were censused to assess chick production.

2. Diet composition.

Diet studies were initiated on 14 January and terminated on 16 February. Depending on weather, 5 diet samples were collected every 5-7 days at the Torgersen Island rookery by stomach pumping (water off-loading method) adult Adelie penguins as they approached their colonies to feed chicks. All birds (N=32) were released unharmed.

3. Chick fledging weights.

Data on Adelie fledging weights were obtained between 3-23 February at beaches near the Humble Island rookery. During this interval, 235 chicks were weighed and released.

4. Length of foraging bouts.

Radio receivers and automatic data loggers were deployed near the Humble Island rookery between 15-28 January to monitor presence/absence data on 21 breeding adult Adelies carrying small radio transmitters. Due to loss of birds and/or transmitters, however, (see Problems and Recommendations) data were obtained on only 12 individuals during the 13 day deployment period.

5. Chick banding.

One-thousand Adelie chicks were banded as part of long term demographic studies at AMLR colonies on Humble Island on 28 January. This effort was aided by 10 Palmer Station and National Science Foundation personnel.

6. AMLR colony mapping.

Maps of the 39 AMLR colonies in the 5 Adelie rookeries near Palmer Station were developed based on aerial photographs and charts obtained with the help of the Argentine Air Force. To minimize disturbance, groundtruthing details of this phase of the work was undertaken after the breeding season (25 February-12 March).

Both indices of Adelie breeding success were lower during the 89-90 season than during the 88-89 season. This season only 59% of the pairs sampled produced 2-chick broods, an 11% decrease when compared to the 70% that produced 2-chick broods during the 88-89 season. Likewise, the number of chicks produced at the 39 AMLR colonies during 89-90 showed a decrease of approximately 20% relative to last season. As last year, the predominant component in the diets of Adelie penguins was the krill *Euphausia superba*. Unlike last year, however, when the predominant size classes of krill evident in the diet consisted of specimens 41-50mm in length (50% of the krill collected), this season krill 31-40mm in length predominated in the diet (60% of the krill collected). Thus, during 89-90 Adelies foraged on significantly smaller krill than during 88-89.

Based on very preliminary results, mean Adelie chick fledging weights did not differ from those evident last season (2.97 versus 3.00kg during 1989 and 1990, respectively). This season, however, the fledging period was somewhat protracted and peak fledging did not occur until 15 February, 4 days later than the 11 February peak fledging period of last season. In 1990, chicks also fledged over the course of a 20 day period (3-23 February) versus a 12 day period in 1989 (5-17 February), suggesting that breeding and/or chick development and growth were somewhat delayed this season. Further conclusions regarding this aspect of the data must await analysis of the telemetry work.

8.3 Disposition of the data:

All diet samples were analyzed and catalogued in the laboratories at Palmer Station, thus no specimens were returned to the U.S. for analysis. These and other data pertaining to this season's research, including information on breeding success, fledging weights, foraging behavior, banding and mapping are currently in our possession and will be made available to the Antarctic Ecosystems Research Group in accordance with formats and procedures used in past years as part of a final report due 1 June.

8.4 Problems, Suggestions and Recommendations:

Because all the penguin rookeries in the study area occur on islands, access is limited to small boats (Zodiacs) that are deployed at Palmer Station. As a result, weather can play a very significant role in determining how often and on what time scales the various rookeries can be visited to meet research objectives. This year weather in the Palmer area was unusually severe, especially during the latter part of the season, which resulted in some variation in the timing of research activities relative to other seasons. Because this variation was minor (2-3 days), however, a negative impact on the overall comparability of the data is unlikely.

It has also become apparent that the amount of winter snowfall clearly impacts the timing of breeding in Adelies and subsequently the chronology of reproductive events during the summer season. Data on early spring conditions thus becomes critical from an interpretive standpoint, in that without it will become increasingly difficult to establish clear links between breeding performance and environmental variability. We are recommending, therefore, that serious consideration be given to funding full season (15 October-15 March) work at Palmer Station. Because this project is currently being cost-shared with NSF through other grants to William R. Fraser and David G. Ainley, all that would be needed would be funds to cover two field assistants from 15 October to 31 December. This relatively small expense would guarantee not only early assessment of spring conditions, but would also permit the gathering of other CCAMLR related data that can only be obtained early in the year.

Finally, although the radio telemetry work done at Palmer Station this year was successful, its true potential was diminished by several factors that affected deployment time and experiment performance. Early in the season, for example, time was lost tracking "noise" sources generated at Palmer Station that interfered with signal reception, while later in the season the entire experiment had to be abandoned due to the planned cleanup and demolition of Old Palmer Station where the equipment was being housed. It also appeared that the radio transmitters provided were larger than necessary for Adelie penguins and this may have contributed to the unfortunate deaths of several birds (as judged by the slowed development and eventual starvation of chicks associated with transmittered parents) early in the experiment. Spent batteries in many transmitters (19 out of 40 originally purchased with AMLR funds) also prevented full use of all the equipment, which if deployed would have roughly doubled the amount of data obtained. Although this problem was identified at our home institution prior to field deployment, funds to correct the situation were not available. We are therefore recommending that in the future funds be provided to purchase smaller transmitters more suitable for Adelie penguins and that these funds include a sum to be used for post-season maintenance of this valuable equipment. The noise sources at Palmer have been identified and eliminated and work will be ordered next year to erect a small housing unit directly on Humble Island to protect the radio equipment.

9. Fur seal and penguin foraging areas near Seal Island; submitted by J.L. Bengtson, P. Boveng, and R.P. Hewitt.

9.1 Objectives:

The CCAMLR Ecosystem Monitoring Program (CEMP) has recommended directed research and monitoring activities in several integrated study areas where investigations of predators, their prey, and the environment should be conducted. An essential element of these integrated studies is linking the results of pelagic prey and environmental sampling with data obtained from land-based monitoring of predators. In order to better understand the relationships between offshore sampling efforts and the studies of fur seal and penguin reproduction, growth and condition, and feeding ecology being conducted at their breeding colonies ashore, it is necessary to obtain information on the foraging areas of these krill predators at sea.

The focus of this study was to determine the foraging areas of selected krill predators (Antarctic fur seals, chinstrap penguins, and macaroni penguins) and to evaluate prey distribution and the environmental features that may affect these areas. Specific objectives were:

1)To identify the foraging areas used by Antarctic fur seals, macaroni penguins, and chinstrap penguins during the 1989/90 austral summer,

2)To determine whether the 1989/90 foraging areas differ from those utilized in previous seasons (i.e., how much flexibility do predators show in shifting foraging areas in response to variable prey resources), and

3)To evaluate the vertical and horizontal distribution of krill in foraging areas as well as the areas passed through in transit to and from feeding grounds.

9.2 Accomplishments:

In preparation for tracking operations from the *Surveyor*, radio transmitters were attached to 10 fur seals, 10 macaroni penguins, and 40 chinstrap penguins. Time-depth recorders

(TDRs) were also deployed on 8 of the 10 fur seals fitted with transmitters. The TDRs were programmed to sample the depth of the seal in the water column every 20 seconds, providing a record of the times and depths of feeding dives. A radio direction finding system was installed on the *Surveyor* to allow tracking the movements of the instrumented fur seals and penguins at sea. This system worked well, with a working radio reception range of 5km (penguins) to 15km (fur seals) from the ship.

Tracking operations were conducted aboard the *Surveyor* from 12-20 January 1990. Tracks to foraging areas were completed for 5 fur seals, 3 macaroni penguins, and 3 chinstrap penguins (Figure 9.1, Table 9.1). In addition, feeding locations were also obtained from a number of shorter trips or incomplete tracks. Each of the fur seals tracked was equipped with a TDR, enabling a comparison of the fur seals' timing and depths of dives with data on krill distribution obtained from hydroacoustic sampling. Because of limited ship time, complete feeding trips were not monitored. Instead, individuals were followed to areas where they made feeding dives and monitored for a period before returning to Seal Island to track another fur seal or penguin. In general, we attempted to follow fur seals for at least 24 hours (25% of a trip), macaroni penguins for at least 12 hours (35% of a trip), and chinstrap penguins for at least 6 hours (50% of a trip).

Table 9.1 Summary of Antarctic fur seals, macaroni penguins, and chinstrap penguins tracked to foraging areas near Seal Island, Antarctica, from 12-20 January 1990. Maximum distance away from Seal Island is indicated. Bearing from Seal Island to the last position observed is also noted.

I.D. no.	Tracking times start track	end track	Elapsed time	Maximum distance	Bearing
Fur seals					
280[a]	12 Jan: 2030	13 Jan: 0544	10.0 h	24 km	340
280	14 Jan: 1830	15 Jan: 2350	30.5 h	100 km	018
042[b]	14 Jan: 2122	14 Jan: 2325	2.0 h	30 km	325
320	17 Jan: 1515	18 Jan: 1400	23.0 h	96 km	353
078[b]	18 Jan: 1925	18 Jan: 2240	3.0 h	18 km	340
520	18 Jan: 2220	20 Jan: 0005	26.5 h	22 km	354
400	19 Jan: 2326	20 Jan: 0800	8.5 h	22 km	340
Macaroni penguins					
670	13 Jan: 0550	13 Jan: 1130	5.5 h	20 km	320
799	13 Jan: 2100	14 Jan: 1000	13.0 h	38 km	358
379	17 Jan: 0220	17 Jan: 1540	13.5 h	35 km	004
Chinstrap penguins					
172	13 Jan: 1643	13 Jan: 2010	3.5 h	22 km	005
291	14 Jan: 1500	14 Jan: 1900	4.0 h	20 km	330
231	16 Jan: 1519	17 Jan: 0134	10.0 h	24 km	015
409[c]	17 Jan: 0707	17 Jan: 0830	1.0 h	11 km	033

NOTES: [a] short, overnight trip; [b] partial track during departure from island; [c] partial track while tracking another penguin

Hydroacoustic data were collected along the track lines of fur seals and penguins en route to foraging areas. In addition, a number of complementary transects were completed between foraging areas and Seal Island (Table 9.2). These transects will provide further information about the distribution of zooplankton along the routes used by these predators in transit to and from preferred feeding localities.

Table 9.2 Hydroacoustic transects between Seal Island and fur seal and penguin foraging areas. These transects complement the data obtained from hydroacoustic records obtained during the tracking summarized in Table 9.1.

No.	Start time	End time	Km from island	Bearing from island
1	13 Jan: 2000	13 Jan: 2200	22	005
2	14 Jan: 0145	14 Jan: 0330	24	001
3	14 Jan: 1000	14 Jan: 1300	38	358
4	16 Jan: 0000	16 Jan: 0800	100	018
5	17 Jan: 0115	17 Jan: 0300	24	025
6	17 Jan: 1200	17 Jan: 1345	26	010
7	17 Jan: 1539	17 Jan: 1800	35	002
8	18 Jan: 1330	18 Jan: 1930	100	353
9	18 Jan: 2245	18 Jan: 2330	20	355
10	20 Jan: 0800	20 Jan: 1300	24	337

Direct sampling of zooplankton was accomplished by towing bongo and MIK nets periodically throughout tracking operations. A total of two MIK net and 11 bongo net tows was made. These samples helped to clarify the type and characteristics of zooplankton evident from the hydroacoustic records.

9.3 Tentative Conclusions:

The foraging areas utilized by fur seals, macaroni penguins, and chinstrap penguins during this season were located mainly to the north of Seal Island; fur seal foraging areas were located at a bearing from Seal Island of between 018° and 325°, macaroni penguins between 004° and 320°, and chinstrap penguins between 033° and 330° (Figure 9.1). In 1987/88 and 1988/89, foraging areas (especially for fur seals) were located more to the north-northwest of Seal Island than during 1989/90. All individuals tracked fed within 100km of the island, with fur seals feeding offshore between 18 and 100km, macaroni penguins feeding between 20 and 35km, and chinstrap penguins feeding between 11 and 24km. This difference in feeding range corresponds well with the different attendance patterns ashore shown by the various species.

During the period of the study, fur seals and penguins feeding closer to Seal Island seemed to be feeding on discrete patches of krill whereas fur seals feeding farther offshore may have had more extensive (and perhaps less dense) aggregations of krill available to them. Further analysis of the dive records from TDRs in comparison with the hydroacoustic data may help to clarify the extent to which the distribution and density of krill varied between different foraging areas and associated dive behaviors.

9.4 Problems, Suggestions and Recommendations:

The tracking operations went very well, with the *Surveyor* proving to be an excellent and effective platform for this type of work. One difficulty encountered resulted from our inability (due to scheduling limitations) to follow fur seals and penguins for their entire feeding trips. Because there was insufficient time to monitor complete trips, it was necessary to make a somewhat arbitrary decision as to when to terminate one track and to start another. Therefore, calculations of maximum foraging ranges will be underestimates of the actual foraging areas that might be used throughout an entire feeding trip. If tracking is conducted in the future, it would be desirable to consider scheduling sufficient ship time to monitor fur seals or penguins throughout their entire feeding trips.

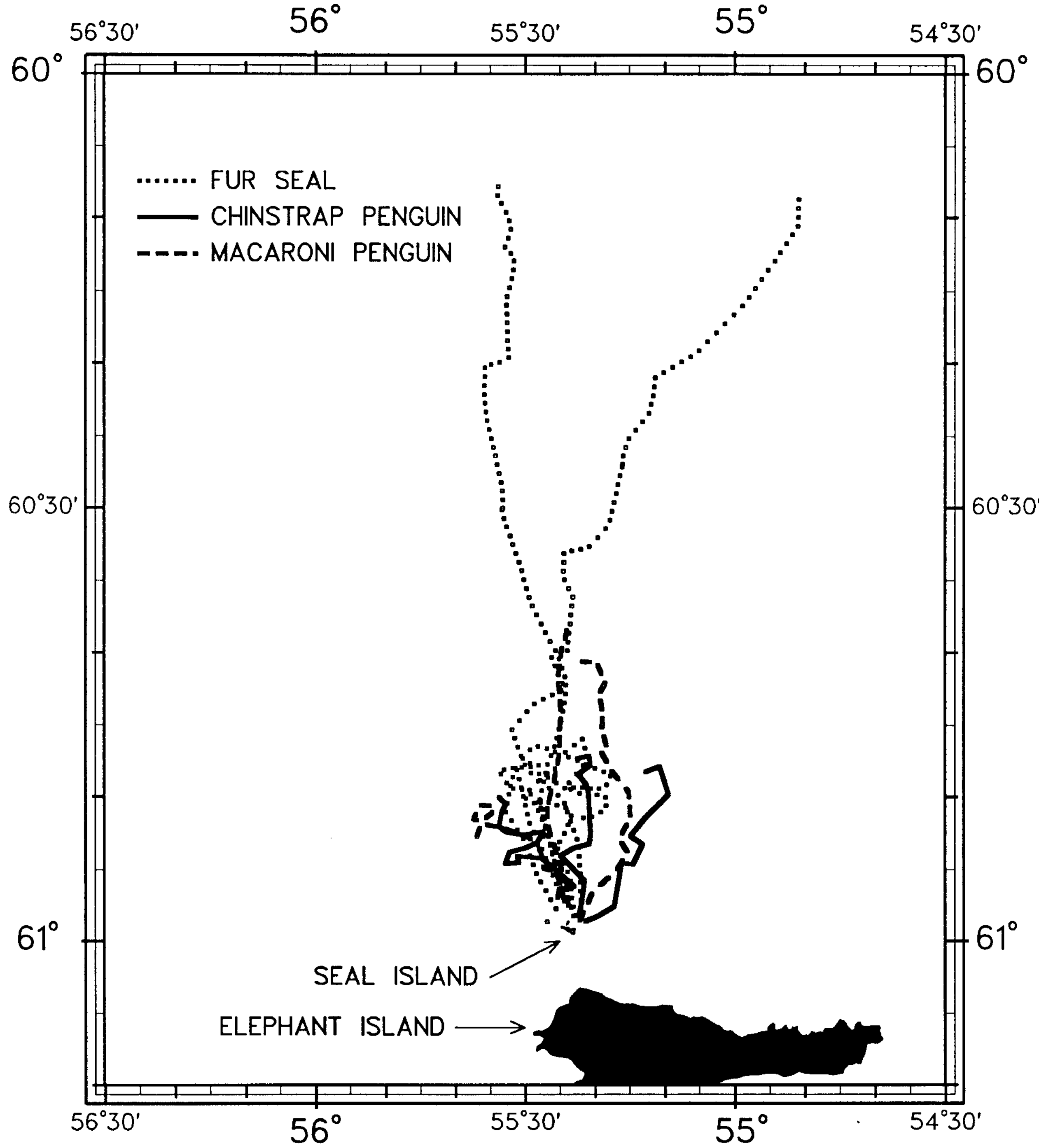


Figure 9.1. Antarctic fur seals, chinstrap penguins, and macaroni penguins tracked to foraging areas near Seal Island, Antarctica, 12-20 January 1990.

10. Crabeater seal research in pack ice areas near the Antarctic Peninsula; submitted by J.L. Bengtson and P. Boveng.

10.1 Objectives:

The crabeater seal has been identified as a priority species for directed research as part of the CCAMLR Ecosystem Monitoring Program. Studies of crabeater seals, which are specialist krill predators in the pack ice zone, complement other AMLR ecosystem research projects conducted in areas that are ice free during the summer but covered with sea ice during the remainder of the year. Specific objectives of the crabeater seal research undertaken this season were:

1)To deploy satellite-linked transmitters on crabeater seals to monitor their seasonal movements and feeding ecology, and

2)To collect specimen material for studies of crabeater seal age structure, reproductive status, physiological condition, and food habits.

10.2 Accomplishments:

Satellite-linked transmitters were successfully deployed on 3 female and 2 male adult crabeater seals just east of Seymour Island in the northwestern Weddell Sea. The instrument packages were attached to the seals' pelage using quick-setting epoxy. Because each of the seals instrumented had already completed its annual pelage molt, it is hoped that the packages will remain attached to the seals for up to 10 months.

The instruments are designed to transmit via the Argos satellite system in 2 modes: 1) a brief status report every 3 days, and 2) a detailed 10-day record once per month. In the first mode, the transmitter attempts to send a summary of diving and haulout behavior for the previous 3 days as well as the seal's current geographic location. Transmissions will only be made if the seal is hauled out during the specified transmission period every 3 days. In the second mode, detailed data on the seals' diving behavior and activity patterns for approximately a 10 day period are collected and transmitted. This detailed data set includes information on individual dives (duration, maximum depth, dive type) made during the sample period. Transmissions for 3 of the 5 seals have been received by the Argos data processing center. The geographic locations and the brief data summaries relayed for these seals suggest that the transmitters are working correctly (Figure 10.1).

The following specimens were collected from crabeater seals sacrificed near Prince Gustav Channel at the northern tip of the Antarctic Peninsula: 1) reproductive tracts, for estimating reproductive status and age at sexual maturity; 2) teeth, for age estimation and calculation of population age structure; 3) blood and urine, for evaluating physiological condition through blood serum chemistry and urinalysis; and 4) stomach contents, to determine the composition and characteristics of prey consumed. Analysis of these samples will provide information on the status and trends of the crabeater seal population and its interactions with other components of the marine ecosystem.

10.3 Tentative Conclusions:

The crabeater seal satellite instruments currently transmitting are working successfully. If these instruments continue operating throughout their anticipated battery life (10 months), they will relay valuable information on changes in the distribution of crabeater seals and their prey as the sea ice moves through its annual advance and retreat.

10.4 Problems, Suggestions and Recommendations:

Maneuvering Zodiac boats through the sea ice while the *Surveyor* remained near the ice edge worked fairly well. However, a principal limitation to this project was the short time available; 4 days were spent working in the ice. Within this brief period, it was not possible to spend much time looking for optimal areas in which to work. Instead, it was necessary to initiate our studies as soon as we found accessible seals, even though the seal densities encountered were relatively low. If similar studies are undertaken in future seasons, it would be desirable to allocate more time in the pack ice for locating areas with suitable densities of seals on workable sea ice, maneuvering the ship, and carrying out the planned research.

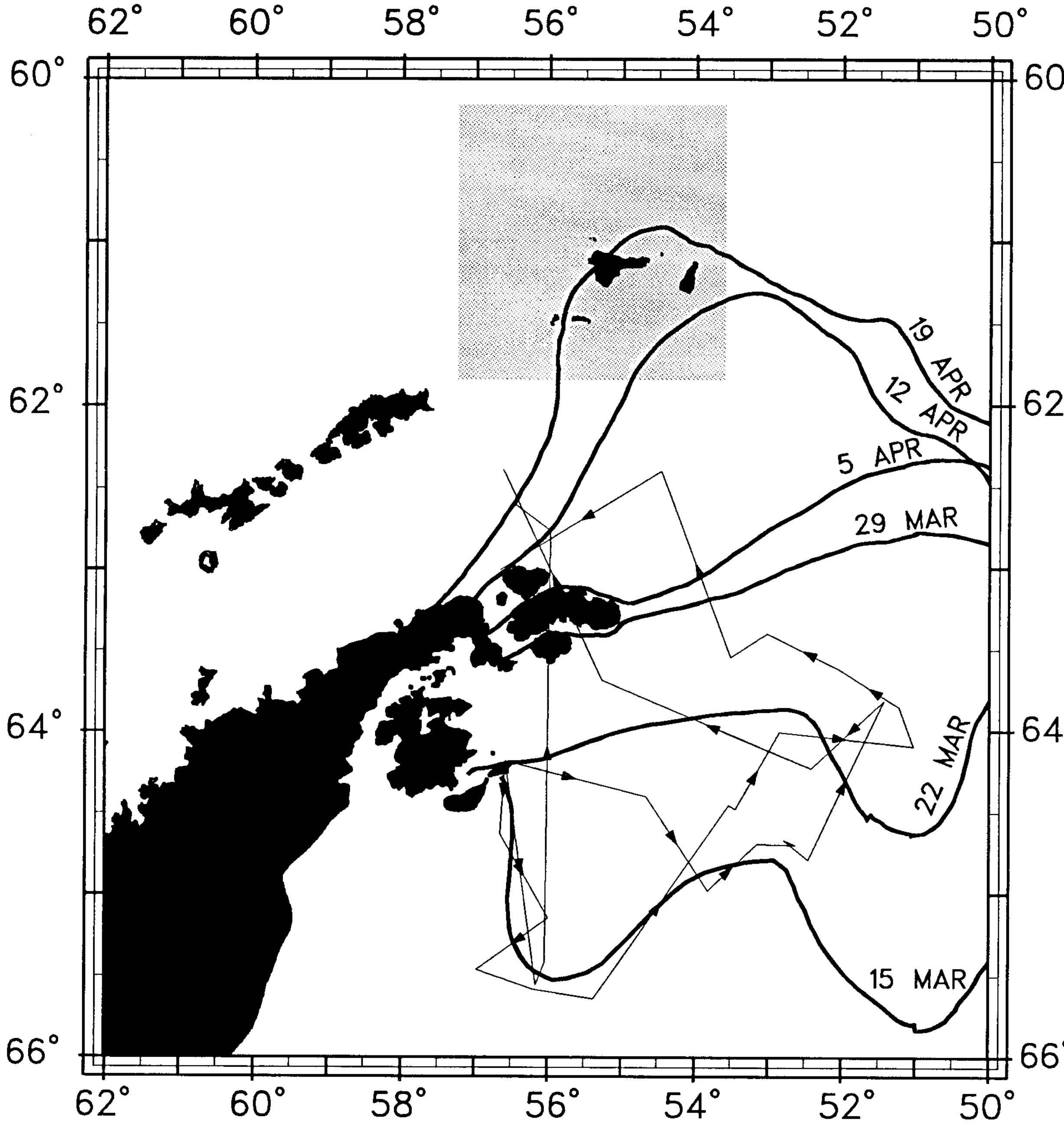


Figure 10.1 Movements of three crabeater seals (thin lines with arrows) tracked by satellite between 16 February and 15 April 1990. Weekly movements of the ice edge (solid lines with dates) are also shown.

11. Seabeam data collection, Leg I and II; submitted by Keith Klepeis, Sarah D. Zellers and Lawrence Lawver.

11.1 Objectives:

Because the NOAA Ship *Surveyor* is equipped with a Seabeam data acquisition system, it represents an unparalleled opportunity to use a U.S. ship to collect valuable data in the circum-Antarctic region. High-resolution, multibeam sonar data can help answer a number of important tectonic questions as well as oceanographic circulation questions. Data were collected during last year's AMLR cruise which we will attempt to combine with the data collected during Legs I and II of the present cruise in order to generate the first detailed bathymetric maps of the Shackleton Fracture Zone (SFZ) and the Elephant Island area. We also hoped to take advantage of this tool to collect the first detailed bathymetric data on the Weddell Sea side of the Antarctic Peninsula. Specific objectives of Legs I and II included:

1) To determine the continuity, morphology, and tectonic structure of the SFZ from the South American continental shelf south of Cape Horn to Elephant Island. Seabeam data for the SFZ study were obtained during transits between Isla Diego Ramirez and Seal Island. We chose the tracklines to compliment the data collected by *Surveyor* during the 1989 AMLR cruise.

2) To conduct Seabeam surveys of the region around Elephant Island. This region includes the intersection of the SFZ with the continental margin of the Antarctic Peninsula. The SFZ has influenced the tectonic structure and rapid uplift of Elephant Island during the recent geological past (4.5 million years ago to present). The Shackleton Fracture Zone represents the active plate boundary between the Scotia Plate to the east and northeast and the Antarctic Plate to the west and southwest. The lateral continuity of this zone and the details of its morphological features are imprecisely known. The Antarctic-Scotia Plate boundary continues across Elephant Island and probably bends eastward around Clarence Island. Seabeam data are critical to trace this feature.

3) To determine the continuity, morphology, and tectonic structure of the South Shetland Trench. The South Shetland Trench is an northeast-southwest trending trench north of the South Shetland Islands. Subduction along this trench was active until 4.5 million years ago when the Drake Plate became incorporated into the Antarctic Plate. Of particular interest is to map the northeast part of this trench as it approaches the SFZ.

11.2 Accomplishments:

The data obtained during the 1990 AMLR cruise were excellent. The Seabeam data collected last year suffered from inadequate navigation control. The *Surveyor* does not have a Doppler speed log, and therefore, cannot accurately know its position between satellite fixes. During the 1989 cruises, the Global Positioning System (GPS) network of satellites only gave 6 to 8 hours of coverage per day. Between the GPS time windows the DR (dead reckoning) positions suffered because there was either inadequate or incorrect navigational data put into the Seabeam system. Seabeam crossings from the 1989 data usually did not agree and some tracks were mislocated by up to 5 nautical miles (n.m.) or more. During this year's cruises, the GPS coverage was nearly continuous, and the few hours that lacked GPS data had transit satellite coverage. Consequently, there was sufficient navigational accuracy such that most of the Seabeam crossings matched. While the position of a few segments of the trackline may be slightly displaced during the times the ship used dead reckoning for navigation, most of these can be easily translated so that they can be matched to the accurately navigated Seabeam framework. Important modifications to the Seabeam software as well as the additional satellite coverage greatly improved the quality of the Seabeam data acquired in the study area.

Seabeam data were collected from the following four areas (most of which are shown in Figure 11.1):

1) South Shetland Trench - Seabeam data were collected during the Leg I southbound transit from Isla Diego Ramirez to the area north of King George Island along a trackline requested by the Pacific Marine Environmental Lab (PMEL--see Appendix Section A.4). This trackline ended just south of the South Shetland Trench. The transit to Seal Island attempted to follow the base of the inner trench wall. Approximately 80 n.m. of Seabeam data were collected along this transit.

2) Elephant Island Area - The majority of the Seabeam data were collected along the krill hydroacoustic survey grid around Elephant Island and during the seal and penguin tracking studies north of Seal Island. Some additional coverage was obtained in two important areas when time and weather allowed. Seabeam data were also collected during transits between Seal Island and the beginning and end points of the hydroacoustic surveys.

3) Shackleton Fracture Zone - Seabeam data were collected along the SFZ during the two northbound transits. The tracklines were chosen to compliment data collected during the 1989 AMLR cruise. Approximately 300 n.m. of Seabeam data were collected along the SFZ during Leg I. Here, the first 50 n.m. of the southbound PMEL trackline parallels and then crosses the SFZ. Neither of the two Shackleton Fracture Zone transects during 1990 were completed. On both legs the transects were broken off well before the intersection of the Shackleton Fracture Zone ridge with the South American continental margin was reached.

(4) Weddell Sea - Due to the unusual ice conditions in the northwestern section of the Weddell Sea, we were able to collect the first detailed bathymetric data in the little surveyed area east of the Antarctic Peninsula.

11.3 Tentative Conclusions:

SOUTH SHETLAND TRENCH

Two segments, one 50 n.m. and the other 30 n.m., of the eastern end of the South Shetland Trench were surveyed. The floor of the trench is approximately 5 n.m. wide with a depth of 4900m where it was crossed at the end of the PMEL trackline. Further to the east, the depth is 5100m. The southern flank of the trench has fairly steep sides; the slope on the northern side is much more gentle in comparison.

ELEPHANT ISLAND REGION

Seabeam data collected northwest of Elephant Island along the hydroacoustic survey tracklines provided detailed information about the SFZ Ridge and the related deep area that parallels it to the northeast. The well navigated data collected in 1990 will be used to better determine the positions of some of the data collected during the 1989 AMLR cruise.

Seabeam data collected during the penguin and seal tracking studies provide excellent bathymetric coverage of the continental margin and slope to the north and northeast of Seal Island in roughly a 5 by 15 n.m. section. This margin is very interesting because it should be a rifted margin if the Scotia Sea opened about 30 million years ago and the Antarctic Peninsula moved apart from the tip of South America at that time. Even though many people believe this simple scenario, the Seabeam data collected this year neatly refute this hypothesis since the angle of the continental slope in the vicinity of Seal Island is on the order of 20° or more, and rifted margins rarely have a continental slope greater than 4°. In some places, the continental slope reached an angle of 40°.

A 6.4m shoal is shown on DMA Chart 29104 approximately 15 n.m. northwest of Seal Island. We have constructed a new chart using Seabeam data collected during this cruise (Figure 11.2). The solid lines are contours based on the Seabeam data, the dashed lines are inferred. This chart shows that if the shoal does exist in its presently mapped location, there must be an extremely steep slope (1100m in 0.5 n.m.) to the north of it. In the Elephant Island region, very steep relief occurs at some of the islands. For example, the elevation of Mt. Bowles on Clarence Island is mapped as 2300m. The bathymetry 3 n.m. to the east of this peak is on the order of 700m. While that relief is approximately 3000m in 3 n.m., it is less than half of what would be required for the 6.4m shoal. It is most likely that the shoal is mislocated; in particular, it may exist further to the south where depths are shallower. Our brief stop at Seal Island confirmed our suspicions that Seal Island lies on the plate boundary between the Scotia and Antarctic plates. Since the 6.4m shoal may also lie on the plate boundary, it is tectonically reasonable to assume that this shoal does exist since the uplift of this shoal area may be related to the same conditions that caused the uplift of Seal Island. The Seabeam data indicated a possible candidate for the plate boundary crossing the continental margin. The submarine canyon that may be the present day Scotia-Antarctic plate boundary is shown on Figure 11.2.

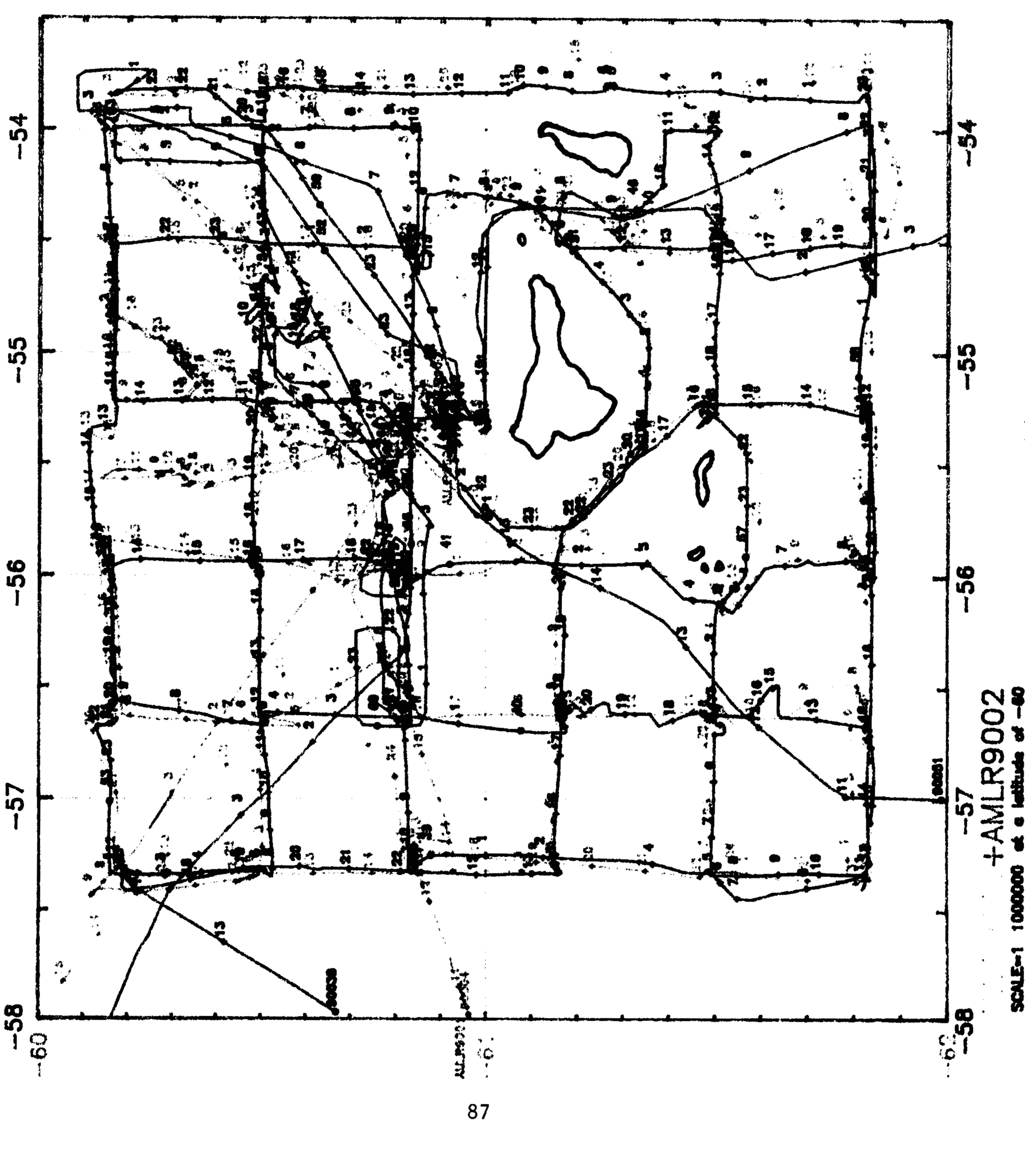
SHACKLETON FRACTURE ZONE TRANSECT:

Seabeam data were collected along the eastern slope of the ridge along the SFZ. This trackline was chosen to map the morphology of the slope of this feature. Previous tracklines (1989 AMLR cruise) mapped the ridge axis and the troughs on either side for the northern and southern end of the SFZ. When comparing prominent bathymetric features, an approximate 2 n.m. discrepancy was noted between last year's and this year's data.

11.4 Problems, Suggestions, Recommendations:

Several times during Legs I and II there were problems with Seabeam software. Along the South Shetland Trench during Leg I, the Eclipse system failed. Approximately 40 n.m. of data were not collected during the three hours that the system was down. The system failed because it was not programmed to record depths exceeding 5000m. This was corrected by adding this and greater depths to the velocity tables within the program. This problem also occurred during the processing of the raw Seabeam data for plotting; however, Chief Survey Technician Gary Nelson fixed this problem and no data were lost.

The vast majority of the problems with the Seabeam data collected during 1989 have been fixed. The lack of adequate navigation has been solved because the number of GPS satellites has increased and the GPS coverage is now approximately 20 hours per day. The *Surveyor* is still without a doppler speed log, which would vastly improve the DR positions during the times that GPS is not available. As we become more dependent on GPS navigation, it is still important that we have a back-up navigation system. Scientific data, whether it is Seabeam, CTD or hydroacoustic data, are worthwhile only if we know where the data has been collected.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SCALE=1 1000000 at a latitude of -60
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Figure 11.1

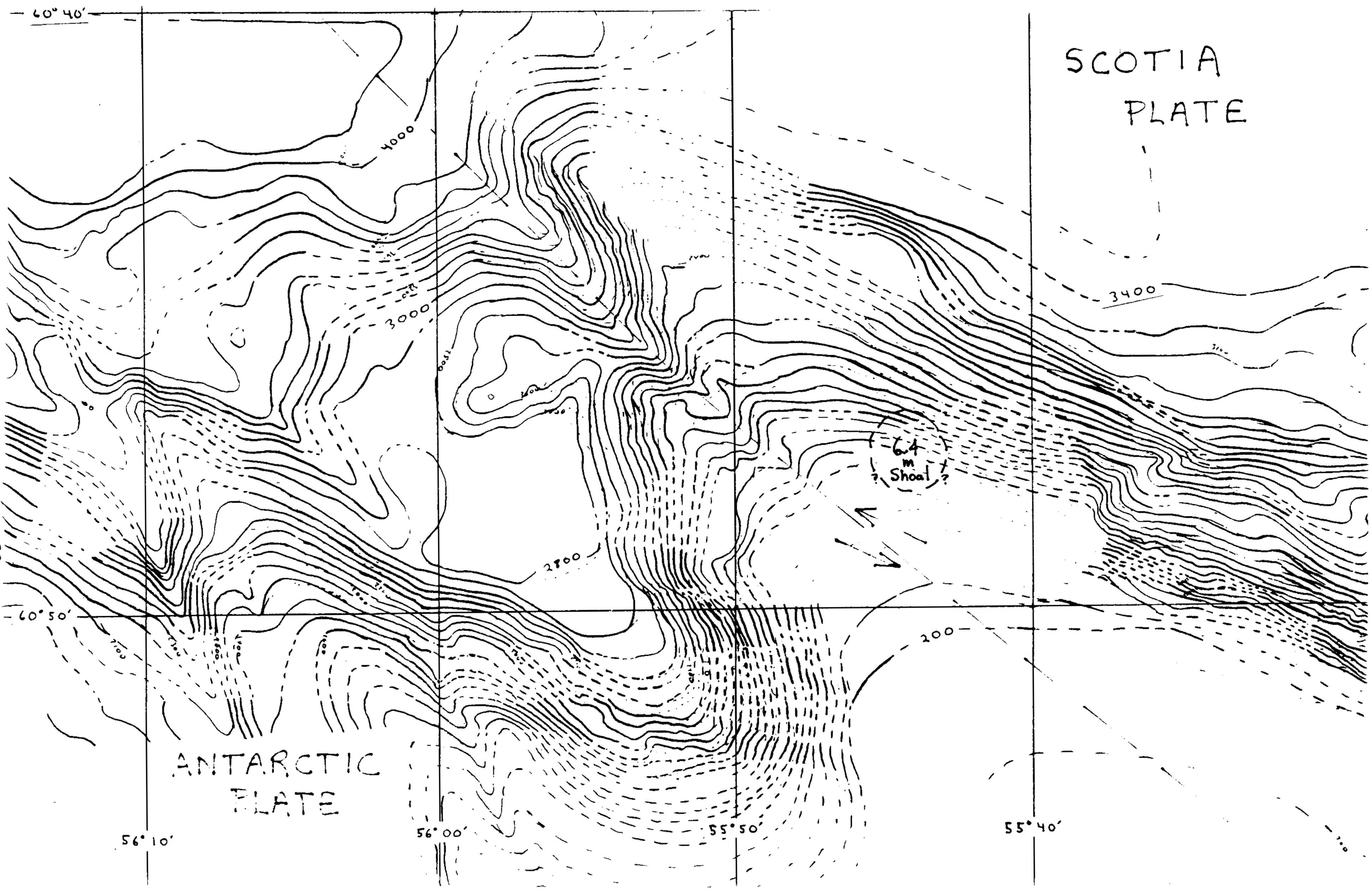
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Figure 11.2

12. Marine mammal survey including genetic variability and stock identity of humpback whales, Leg I and Leg II; submitted by Philip Hamilton and Kim Robertson.

12.1 Objectives:

Our primary objectives were the censusing and photographic identification of individual humpback whales during ship operations and the collection of small skin samples from identified individuals in order to determine: 1) regional abundance and local distribution; 2) levels of genetic variability; and 3) the genetic relationship of the Antarctic Peninsula stocks to other stocks in the southern hemisphere and to conspecific populations in the North Pacific and North Atlantic Oceans. Local distribution is determined through sightings recorded from *Surveyor's* flying bridge during all operations (transit, krill surveys, and predator studies). Regional abundance is estimated using capture-recapture analysis of individual identification photographs collected across years. Genetic variability and stock identity are described using restriction fragment length polymorphisms and sequence variations of mitochondrial DNA extracted from biopsy samples of skin tissues. Migration patterns are then ascertainable through matched photographs and/or genetic comparisons to northern latitude stocks.

Our secondary objectives were to complete a census of all marine mammals from Valparaiso, Chile to Antarctica and to test for statistical correlations between mysticete whale sightings and krill densities as determined by the hydroacoustic surveys.

12.2 Accomplishments:

Marine mammal observations were conducted on 58 days during the months of December, January, and February. Watches were conducted from sunrise to sunset, with alternating two- to three- hour shifts split between two observers. Cetacean and seabird sightings were recorded for each 15-minute transect when the vessel was underway at a speed of 7 knots or more. General or "off effort" observations were made when the ship was maintaining a speed of less than 7 knots or was at either station or at anchor; these observations will not be included in abundance estimates. Observations totalled 452.5 hours of effort and are broken down as follows:

	LEG I	LEG II
Inside Passage (Valparaiso to Punta Arenas):	32.2	--
Transits through Drake Passage:	35.0	16.7
Hydroacoustic Surveys around Elephant Island:	144.5	122.0
Seal/Penguin Tracking; Ice Seal Studies:	24.7	77.2

Three species of mysticete and seven species of odontocete whales were recorded. Any sightings south of 57 degrees latitude were considered part of Antarctica. The table below summarizes all cetacean sightings for both legs of the 1989-90 cruise:

	Antarctica Leg I	Antarctica Leg II	Valparaiso to Punta Arenas	P. Arenas to Drake
Humpback Whale	5	1	--	2
Finback Whale	24	37	--	--
Minke Whale	19	109	1	9
Sperm Whale	4	1	1	--
Orca	2	7	3	--
Pilot Whale	--	648	--	--
Hourglass Dolphin	--	199	--	4
Dusky Dolphin	4	--	207	52
Southern Right Whale Dolphin	--	--	260	--
Southern Bottlenosed Whale	60	--	--	--

Fifteen of the 109 minke whales on Leg II were seen near Elephant Island; this number is consistent with the sightings from Leg I. The other 94 minkes seen during Leg II were sighted further south near the pack ice. There were no sightings of southern bottlenosed whales on Leg II. However, almost 200 hourglass dolphins and 648 long-finned pilot whales were sighted during February in the same area where they had been completely absent the month before. Finback whale sightings remained consistently high during both legs. Orcas were seen in the inside passage of Chile, in the waters north of Elephant Island, and near the Antarctic peninsula close to the pack ice.

A total of eight humpback whales were sighted. Six of those were seen during the hydroacoustic surveys around Elephant Island. The other two were sighted near Tierra Del Fuego. One attempt was made at obtaining skin samples and photographs of a single humpback on Leg II. The animal proved to be elusive and repeatedly avoided the boat. After an hour of following the whale, we still could not get close enough for a darting attempt. Sea conditions were not favorable for continuing. Unfortunately, no skin samples or photographs were collected.

Krill data were presented to us for 22 days covering 32 sightings of 71 mysticete whales. Tests for statistically significant correlations between the two will be conducted. In 1987, a strong correlation was evident between minke whale sightings and krill concentrations (Stone 1987). This year, relatively few minkes were sighted in the krill study area. Unfortunately, no hydroacoustic information was available for the area near the ice where minke whale concentrations did occur.

A copy of all marine mammal sightings will be given to the *Surveyor* in a format which complies with their ongoing log of marine mammals.

12.3 Tentative Conclusions:

During both legs of the cruise, we observed two apparent changes in cetacean occurrence for the Elephant Island area: an increase in fin whale sightings and a decrease in minke whale sightings.

The total of 61 fin whales sighted this season was unprecedented. Records of live mysticete whales for the Antarctic Peninsula area during recent years include sightings of only minke, humpback, and right whales (Bonner 1982; Leatherwood et al. 1982; Erickson et al. 1983; Ohsumi 1983; Stone and Hamner 1988; Stone 1987). There have been no recent reported sightings of fin, sei, or blue whales.

In previous years, minke whales were the most abundant mysticete whale sighted in the Elephant Island area. The 19 and 15 minkes sighted during Leg I and II respectively is a considerable decrease from the 86 minkes sighted in the exact same area in January '87 (Stone 1987).

These apparent changes in minke and fin whale occurrence have appeared concurrently with a movement of the Antarctic pack ice considerably south of its location in previous years. This retreat in the ice may have effected the physical and biological parameters which determine whale occurrence, in turn causing a southward shift for some whale species. The observed concentration of minke whales (94 animals) closer to the ice edge would support this hypothesis. Also, as all fin whale sightings consistently occurred north of Elephant Island, it is possible that fin whales were undocumented in previous years because they were using the little surveyed waters further north in the Drake Passage. A southerly migration from that area would place them just north of the Elephant Island group.

12.4 Problems, Suggestions and Recommendations:

Our sightings indicate that further investigation of cetacean abundance is warranted in the Antarctic Peninsula area. Sightings of 195 mysticete whales and 722 odontocete whales (925 with dolphins) indicate that these waters are still important for both suborders of cetaceans. This region is also subject to an active krill and fin-fish fishery which could potentially compete with both marine mammals and birds for their primary prey (FAO 1984,1985). Competition for prey resources could slow or reverse the recovery of endangered species, including the mysticete whales. Although catch records from this area indicate intensive harvests of most mysticete species (Mizroch 1984, 1985;BIWS 1987), current estimates of abundance and assessments of population trends can only be considered "best guesses" until more data are collected. Furthermore, continued effort will help determine whether this years apparent change in mysticete occurrence and distribution is real and if so, what some of the causes may be.

In addition to further effort in the Elephant Island area, several days of survey closer to the west side of the Peninsula (preferably the Gerlache Strait) would facilitate photographic and tissue sampling of humpback whales. The scarcity of humpbacks in the Elephant Island area may be temporary; however, the western side of the Peninsula offers consistently higher numbers of humpbacks and generally calmer seas in which to work them.

We would like to thank the crew and officers for their support. We especially thank the bridge watch for recording positions, the field operations officers, Lts. Craig Berg and John Miller, and the deck crew for deploying and operating the R.H.I.B. In the scientific party, we wish to thank Tony Amos and Margaret Lavender for assistance in plotting whale sightings and Mike Macaulay and Pat Morrison for supplying us with krill density data.

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Leg I

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    Michael Macaulay, University of Washington
    Adrian Madirolas, INIDEP, Argentina
Direct krill sampling:
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    Stephen Berkowitz, Texas A&M University
    Chul Park, Chungnam National University, South Korea
Physical oceanography:
    Anthony Amos, University of Texas at Austin
    Margaret Lavender, University of Texas at Austin
    Ricardo Rojas, IHA, Chile
Phytoplankton distribution:
    Osmund Holm-Hansen, Scripps Institution of Oceanography
    Walter Helbling, Scripps Institution of Oceanography
    Sergio Rosales, Catholic University, Chile
Predator tracking studies:
    John Bengtson, National Marine Mammal Laboratory
    Peter Boveng, National Marine Mammal Laboratory
Seabeam data collection:
    Sarah Zellers, University of Texas at Austin
    Mary Ann Lynch, Scripps Institution of Oceanography
        (southbound transit only, San Diego to Valparaiso)
Marine mammal observations:
    Philip Hamilton, New England Aquarium
    Kim Robertson, College of the Atlantic

Leg II

Cruise Leader:
    Rennie Holt, Southwest Fisheries Center
    Izadore Barrett, Southwest Fisheries Center
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    Kendra Daly, University of Washington
    Patricia Morrison, University of Washington
    Sam McClatchie, Cornell University
Direct krill sampling:
    Valerie Loeb, Moss Landing Marine Laboratories
    John Wormuth, Texas A & M University
Physical oceanography:
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    David Ainley, Point Reyes Bird Observatory
Marine mammal observations:
    Philip Hamilton, New England Aquarium
    Kim Robertson, College of the Atlantic
Bird observations:
    Ian Gaffney, Point Reyes Bird Observatory
    Larry Spear, Point Reyes Bird Observatory
        (northbound transit only, Iquique to San Diego)

ACKNOWLEDGEMENTS

The scientific party expresses its appreciation to the Captain, officers, and crew of the NOAA Ship *Surveyor* for their dedication to the success of the cruise. We were impressed not only with the professionalism and integrity of all aboard, but also with the friendliness and enthusiasm extended to us and to our work. We value the outstanding efforts of the entire ship's complement. Several personnel were particularly instrumental to the success of the cruise: the electronic technicians on both legs, who never hesitated to drop what they were doing to work on our equipment; King Claggett and his deck crew who carefully handled our equipment as if it were their own; our stewards, Carol Caroll and Tammy Tyner, whose considerations were beyond the call of duty; and Craig Berg and John Miller, Operations Officers, who managed the ship's resources in our behalf. We had a very successful cruise, and we are appreciative to those who made it possible.

APPENDIX

A.1. Seabeam data collection and preliminary interpretation, Southbound transit; submitted by Mary Ann Lynch.

A.1.1 Objectives:

There were two scientific objectives to be met on this transit. The most important was to conduct a Seabeam survey of parts of the complex and poorly mapped Sala y Gomez Ridge and Easter Fracture Zone region, which lies between 101° and 82° W, and between 23° and 26° S. The Sala y Gomez Ridge is in a region of unusually complex tectonic history, including a well documented ridge jump during the Oligocene and a currently active ridge jump. This activity has left numerous relics on the sea floor east of the Easter microplate and has made the area the object of much scientific speculation. Except for one small area on the west end of the Sala y Gomez Ridge, all surveying of the region has been conducted by ships of opportunity. The patchy coverage which has resulted, combined with the major tectonophysical significance of the region, has permitted widely divergent interpretations of the area's history to share equal credibility within the community of interested scientists. The survey conducted by the *Surveyor* was aimed at closing some of the gaps in coverage of the ridge and at testing the major hypotheses concerning its origin and significance.

The second objective of the transit was to follow a GEOSAT altimeter track from just off the California coast to its intersection with the Sala y Gomez Ridge. Seabeam data collected along this line will be used to test the correspondence between bathymetry and GEOSAT gravity measurements.

A.1.2 Accomplishments:

During the first six days of the transit, the ship was unable to collect digitized Seabeam data along the trackline due to damaged cables in the electronics system. Analog data were collected on the swath plotter, although it is uncertain what its utility will be. Because the original trackline was so long, however, a substantial amount of bathymetric data were collected after Seabeam function was completely restored. On the west side of the East Pacific Rise, the sea floor bathymetry was fairly smooth abyssal hill topography, much as we had expected. On the west side of the East Pacific Rise, however, the bathymetry was surprisingly varied; numerous seamounts appeared, and lineations followed unexpected directions.

The ridge survey went extremely well. The cooperation of Captain Stubblefield, Navigation Officer John Miller, Operations Officer Craig Berg, Chief Survey Tech Gary Nelson and the Survey Watch, and of the Bridge watches made it possible to accomplish a surprising amount in the 48 hours of the survey. Directed surveys allowed areas where we suspected that there would be significant features to be targeted, and surveyed completely enough to test specific hypotheses about their nature.

The survey began at the east end of the Sala y Gomez Ridge, at approximately 24° 45' S 99° 30' W, crossed the ridge on a transect to the southeast, then turned to the east, to map a suspected en-echelon ridge system. During this survey a major guyot rising to 400m was discovered at 25° 37' S and 95° 36' W. This was just one of a number of uncharted seamounts found during the course of the work. At approximately 96° W, the ship began a survey line across the ridge to the northeast, in an attempt to map a conjugate ridge system. This turned out to be an elevated strip of sea floor, crowned, at intervals, by guyots. At this point the survey terminated, and the ship turned to begin the run to Valparaiso, crossing the ridge one final time, and mapping one final new guyot at its southern edge.

A.1.3 Disposition of Data:

All centerbeam sonar records and all original digital data will be forwarded to the NOAA Office of Charting and Geodetic Services for final post processing, reproduction and distribution to Dr. David Sandwell, Geological Research Division, Scripps Institution of Oceanography.

Copies of the digital data, and one set of paper plots, as well as swath plots from the entire survey will be hand carried by Mary Ann Lynch, to be returned to the Scripps Institution of Oceanography. After analyses, these materials will be archived by the Geological Data Center of the Scripps Institution.

A.1.4 Tentative Conclusions:

As presently mapped the Sala y Gomez Ridge is a welter of mismatched ridges and seamounts, each with its own distinguishing characteristics and orientation. At least five different orientations are represented among the subsidiary volcanic ridges of the Sala y Gomez Ridges. This is a major obstacle to understanding their origins, since cracks in the sea floor leading to the creation of ridges should reflect the influence of the direction of regional stress. The results of the survey indicate that the N 65°W trending ridge at the northwest end of the Sala y Gomez Ridge does not exist save as a slightly elongate seamount. This eliminates one entire ridge orientation. Two southerly ridges, represented on the GEBCO map, Sheet 11 (Mammerick and Smith, 1980), appear to be parallel en-echelon features, trending N 85°W.

This simplification of the structure of the ridge, as well as the discovery of new seamounts suggests that the morphology of volcanic structures on the ridge was strongly influenced by some kind of regional stress that determined the direction of orientation for most of the features in the area. The other major influence on direction is the Easter Fracture Zone, which appears to have determined the direction of the only ridge not trending northwest. Only that one ridge appears to have been affected by the fracture zone, and so it seems reasonable to conclude that the Sala y Gomez Ridge is not a "leaky" fracture zone, but results from the interaction of regional stress and local magmatism. This interpretation is in keeping with the alkali basalt composition of rocks dredged from these ridges.

It has been postulated that the Sala y Gomez Ridge is an incipient spreading center because of the apparent swell of the sea floor along it. The data collected on this cruise support this conclusion, in that they indicates the presence of unusually strong, directed tension in the same area in which incipient cracking and magmatism are occurring.

A.1.5 References Cited:

Mammerick, J. and S.M. Smith (1980), General Bathymetric Chart of the Oceans, 5th Ed., Canadian Hydrographic Service, Ottawa, Canada.

A.2. Observations of Seabirds in the Humbolt Current and Eastern Tropical Pacific, Northbound Transit; submitted by Larry Spear and Ian Gaffney.

A.2.1 Objectives:

Our primary objective was to census seabirds over the continental shelf (depths less than 200m) of Peru between altitudes 15°S and 5°S during the *Surveyor's* northbound transit from Iquique, Chile. These data are needed for a study begun in 1985 by Dr. David Ainley and Larry Spear of seabird assemblages found in the ocean habitats that compose or are affected by the Humbolt Current, which flows northward over the continental shelf of Peru and Chile. The ocean habitats are distinct with respect to sea surface temperature (SST) and salinity (SSS) and thermocline depth and slope. Although the Humbolt Current system is known to be one of the most productive ocean systems in the world, little quantitative information is available regarding its avifauna, which includes many endemic species.

Our second objective was to census seabirds as the *Surveyor* transited from Peru to a survey area at approximately 13°N, 128°W, and then to San Diego. The purpose of this effort was to gather data for an ongoing study begun in 1983 by David Ainley on seabird assemblages of different water masses of the Eastern Tropical Pacific.

A.2.2 Accomplishments:

We counted all birds seen within an area extending 300m from the ship, and between points directly off its bow to directly off one beam or the other, depending on glare off the water. Censuses were conducted continuously during daylight hours with one person scanning with hand-held binoculars for low flying birds while the other watch mostly without binoculars for birds flying higher and for those flying nearer the ship. The ship's officers and crew recorded the ship's position, course, speed, ocean depth, and distance to land at half hour intervals, and the Survey Department took hourly bucket samples for SST and SSS determination. They also launched four XBT's daily and provided us with a graphed profile for each.

During 21 and 22 March 1990, we conducted 25 hours of seabird censuses along 357 n.m. of trackline (198km^2 of surface area censused) over the continental shelf of Peru between the latitudes 14°30'S and 7°00'S.

Between 23 March and 9 April 1990, as the *Surveyor* steamed from northern Peru to San Diego, we conducted 217 hours of censuses along 2995 n.m. of trackline or 1662km^2 of transect area censused.

A.2.3 Disposition of Data:

Data recorded will be entered into the files of Dr. David Ainley and Larry Spear at the Point Reyes Bird Observatory, Stinson Beach, California.

A.2.4 Tentative Conclusions:

The biomass (kgs of birds per km^2) and perhaps species diversity of the avifauna occupying waters over the continental shelf of Peru is probably the largest of any marine community.

A.2.5 Problems, Suggestions and Recommendations:

The *Surveyor* is an excellent platform for observing seabirds. The 25 x 150mm mounted binoculars should become a permanent feature if future bird work is planned. These binoculars are sometimes the only means for identifying species of seabirds in the field. They should be mounted on the starboard side of the flying bridge because vibration is greater on the port side at speeds over 12 knots.

A.2.6. Acknowledgments:

The scientific party thanks the *Surveyor's* officers and crew for their cheerful assistance throughout the cruise. We are especially grateful for the support we received after leaving the coast of Peru. We had not planned to census birds to San Diego -- this was not in the Cruise Instructions. Yet everyone helped without hesitation. Persons we thank in particular are Lieutenant Commander Craig Berg, whose intuitive foresight kept things running smoothly, and Tammy Tyner for bringing our lunches to the flying bridge every day. We thank Captain William Turnbull for making a last minute request for clearance to run closer to the Peruvian coastline than we had originally requested, and for allowing one of us to continue observations from the flying bridge during drills.

A.3. Thermal Structure and Geostrophy in the Drake Passage, Leg I and Leg II; submitted by Ricardo L. Rojas and Alejandro Cabezas C.

A.3.1 Objectives:

During the 1990 AMLR cruise aboard the NOAA ship *Surveyor*, a research project in the Drake Passage was conducted and funded by the Chilean Navy Hydrographic Institute (IHA.). The objectives of this research included a) monitoring the thermal structure of the upper layers of the Drake Passage, b) identifying mesoscale features of the Antarctic Circumpolar Current (ACC) in that area, and c) making a new estimate of the geostrophic flow across the Polar Front using CTD observations. Two tracks were performed during each leg of the AMLR 1990 Cruise.

A.3.2 Accomplishments:

During Leg I, observations were made crossing the Drake Passage from south of Diego Ramirez Islands to about 60 n.m. offshore of the South Shetland Islands and during the return trip, from Elephant Island up to Cape Horn (Figure A.3.1). These measurements consisted of 18 expendable bathythermograph casts (XBT) launched at regular intervals across the Passage using the SEAS (Shipboard Environmental Acquisition System) unit of the ship, which allows for magnetic data storage. During the crossing the ship maintained a continuous recording of sea surface temperatures and salinities, as well as meteorological data. At some CTD stations during Seal Island studies, XBTs were launched for calibration purposes. On the return crossing of the Drake Passage, 18 XBTs were launched and three deep (2600m) CTD casts were performed at the center of the Passage (see Figure A.3.1). The CTD (Sea-Bird SBE-9) was provided by Dr. Anthony Amos, from the University of Texas, Austin, and Dr. Amos and Ms. Margaret Lavender kindly operated the instrument while at stations.

During Leg II of the cruise, bathythermometric data were collected on two more trips across the Drake Passage (Figure A.3.2). In the track from north to south, 9 expendable bathythermograph casts (XBT) were launched at regular two-hour time intervals using the SEAS unit of the ship. During the return track, another 14 XBT casts also were made at regular two-hour intervals. Due to rough weather and sea conditions, we were unable to complete all 19 XBT's initially scheduled. Also, we had the opportunity to perform 3 CTD casts in the same positions as those made during the Leg I (Figure A.3.2). However, due to weather and sea conditions, we were able to complete only two of them. The CTD was kindly operated by Ms. Margaret Lavender, University of Texas and Dr. Izadore Barrett, Southwest Fisheries Center, to whom we express my deepest gratitude.

A.3.3 Tentative Conclusions:

Regarding the data from the first XBT-line across the passage during Leg I, the thermal structure of the upper layers showed the expected pattern found in previous transects (Nowlin et al, 1977; Whitworth, 1980; Sievers y Nowlin, 1986). The Subantarctic Front (SAF) and the Polar Front (PF) were located approximately at 58° S and 59° S, respectively, separating the waters of the Subantarctic Zone (SAZ) and the Polar Frontal Zone (PFZ). The Continental Water Boundary (CWB), a front located close to the Antarctic continent, was not found on this first track because the XBT-line did not reach the coastal waters of the South Shetland Islands. South of the PF, and below 100m, a cold water core was found. This core is produced by summer heating of the surface layers. Figure A.3.3 shows a preliminary description of the thermal structure spanning the Drake Passage. By the time of this report, neither the return XBT-line was analyzed, nor were CTD data available for geostrophic calculations. No data from Leg II had been analyzed at the time of this report.

The authors want to express their gratitude to the Captain, officers and crew members of *Surveyor*, as well as the chief scientist, Dr. Roger Hewitt, and Dr. Amos for allowing them to perform the unscheduled CTD casts.

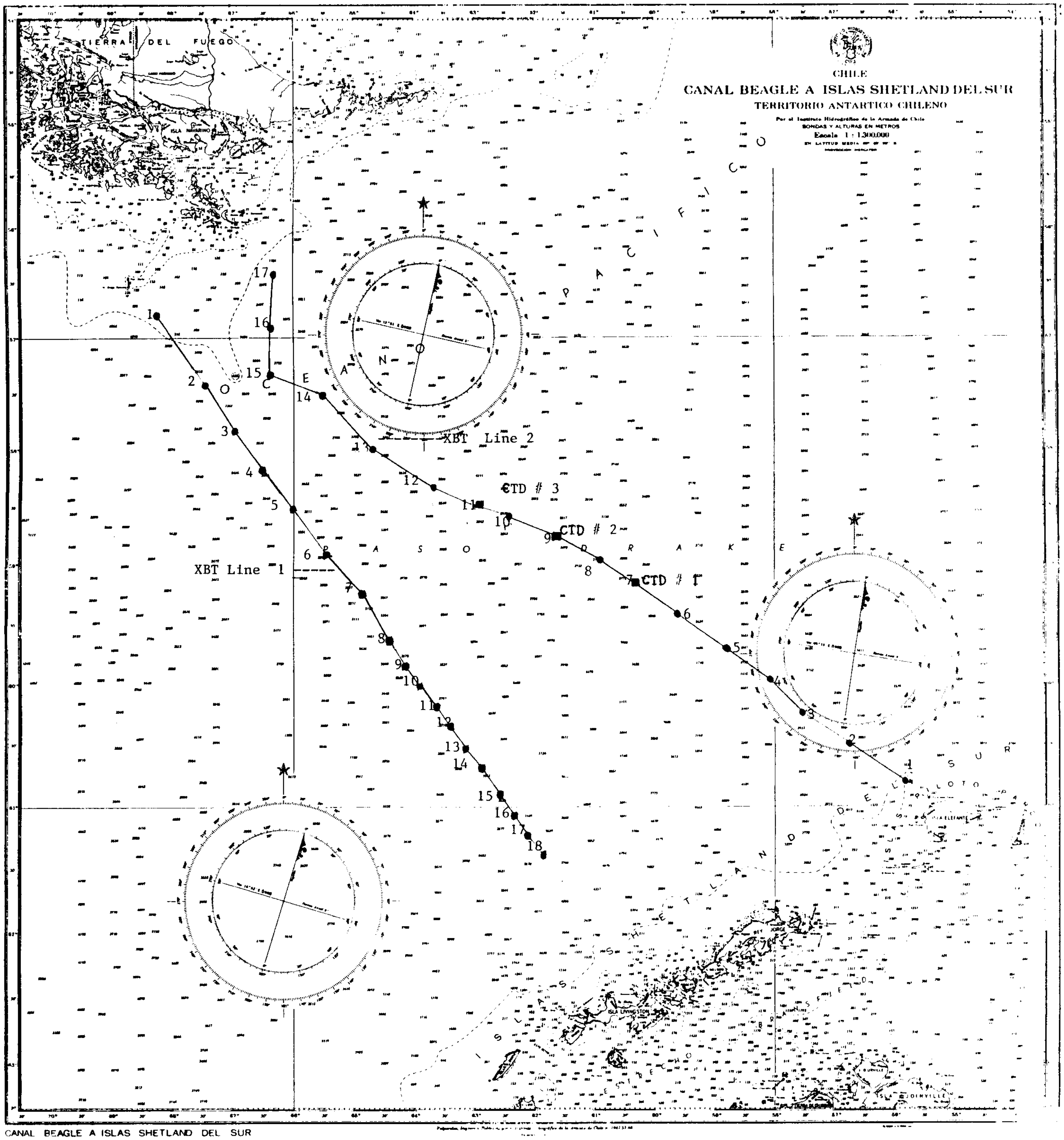

Figure A.3.1 Position of XBT launches during the crossing of the Drake Passage on January 4-5 (Line 1) and January 28-29 (Line 2). The positions of the CTD stations are also shown (squares).

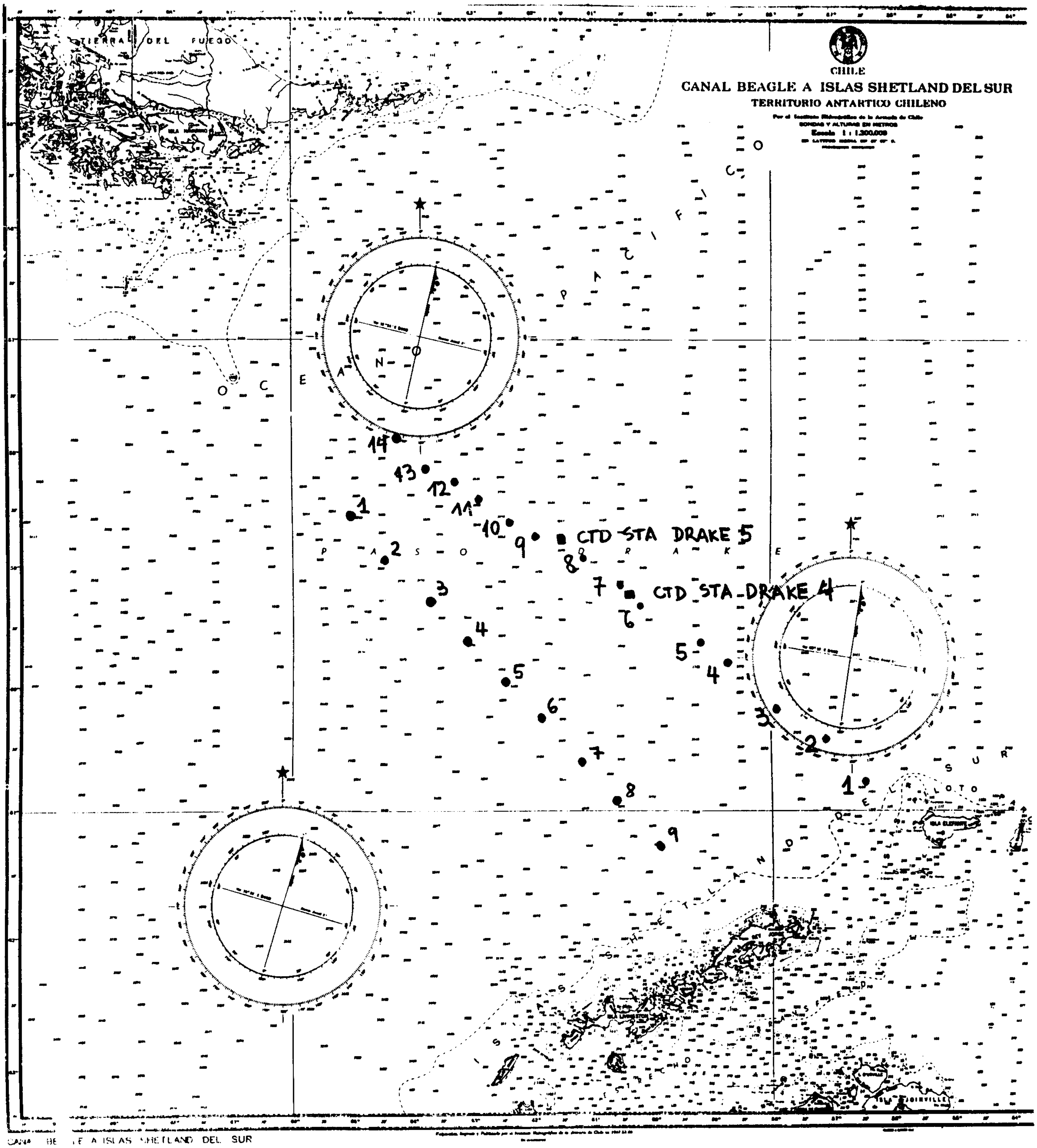

Figure A.3.2 Position of XBT launches during the crossing of the Drake Passage on Leg II. The positions of the CTD stations are also shown (squares).

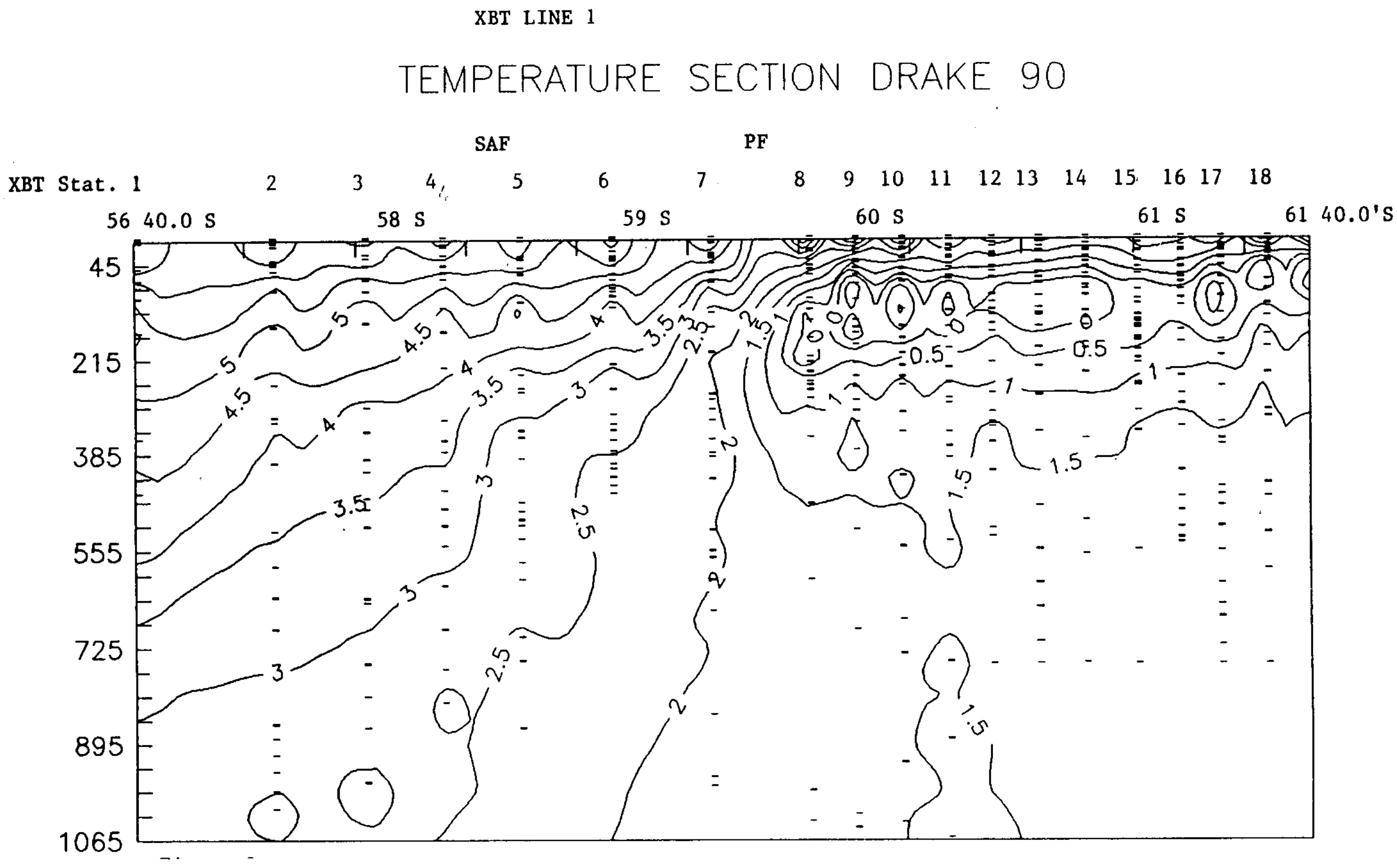

Figure A.3.3 Preliminary temperature section across Drake Passage (Jan. 4-5, 1990) during the travel between Diego Ramirez Island and South Shetland Islands (150° true). SAF (Subantarctic Front), PF (Polar Front).

A.4. Ancillary Data Collections

A continuous record of sea surface temperature and salinity was maintained. The data, on magnetic format and hard copy, were released to the Chief Scientist. An annotated position log was prepared by the ship's personnel and released in hard copy and electronic spreadsheet file formats to the Chief Scientist. Hard copies of the bridge weather logs were also provided to the scientific party.

In response to a request from Pacific Marine Environmental Laboratories (PMEL), Seabeam data were collected along two tracklines from the vicinity of Isla Diego Ramirez to points north of the South Shetland Islands. The ship will provide a copy of these data to PMEL.

A.5. Report of U.S. CCAMLR Inspection of Japanese R/V *Aso Maru*; submitted by Laura L. Claywell

United States CCAMLR Inspector Laura L. Claywell, on board the NOAA Ship *Surveyor* (WTES), made radio contact with the master of the Japanese F/V *Aso Maru* (JMVD) on March 1, 1990. Permission was requested to board the vessel to conduct an inspection under, and in accordance with, CCAMLR's "System of Observation and Inspection". The ship's master, Captain Hiroaki Mega consented, but cautioned that the ship was fishing and its nets were in the water.

The position of *Surveyor* was determined to be 60°37.2'S, 054°56.4'W at 1330 GMT, using GPS navigation system. Inspector Claywell then boarded the F/V *Aso Maru* accompanied by Chief Scientist AMLR, Dr. Rennie Holt and biologist Dr. John Wormuth of Texas A&M University. The party arrived on deck at 1320 GMT and were escorted to the Captain's cabin. They identified themselves to Captain Mega and discussed the inspection procedures. Captain Mega was aware of the CCAMLR inspection program.

Captain Mega provided Inspector Claywell with information concerning the vessel owners, trawl type, net plan, and log books. They discussed (to the best ability of Captain Mega to speak English) the type of information logged on board the ship. This included tow information, weather logs, catch records, and searching logs. It was explained that two nets were presently in use to fish for krill. They were both mid-water pelagic nets, one currently in the water, and one unrigged.

The inspection team was then notified that the net was being hauled onboard and they were escorted to the bridge at which time the ship's position was recorded as 60°39'S, 054°55'W at 1400 GMT. The team was then taken down to the working deck to view the codend as it came on deck (which appeared to be all krill), and then below to the processing deck to view their operations. Inspector Claywell determined it was unnecessary to measure the nets due to no CCAMLR Conservation Measures restricting mess sizes for krill fishing, and no evidence of any other species of fish on board. Captain Mega reported virtually no by-catch of fish or squid, and no incidental catches of birds or marine mammals in their trawls. The CCAMLR placard was openly displayed as was the Radio Call Sign. Captain Mega reported no fishing gear was lost or any seen, nor any bird or mammal entanglements observed.

No infringement of CCAMLR Conservation Measures was observed, and the F/V *Aso Maru* was found to be complying with all CCAMLR requests. Captain Mega and Inspector Claywell both signed the report and a copy was given to Captain Mega. At 1430 GMT the inspection team disembarked the ship.

The inspection team found Captain Mega to be most cooperative and helpful during the inspection. His ability to speak English was critical since Inspector Claywell did not receive the list of questions or reporting forms in Japanese. Although the team was able to communicate most questions, there were some that were not understood, and some vaguely at best.